Special Supplement
SMITHSONIAN ASTROPHYSICAL OBSERVATORY
BULLETIN NO. 8
FOR VISUAL OBSERVERS OF SATELLITES

Sky and TELESCOPE

In This Issue:

Irregularities in the Earth's Rotation — I

More Satellite Talk

Among Southern Galaxies — NGC 253

Henri Poincare and His Cosmogonical Studies

American Astronomers Report

Stars for March

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Vol. XVII, No. 5

MARCH, 1958

50 cents

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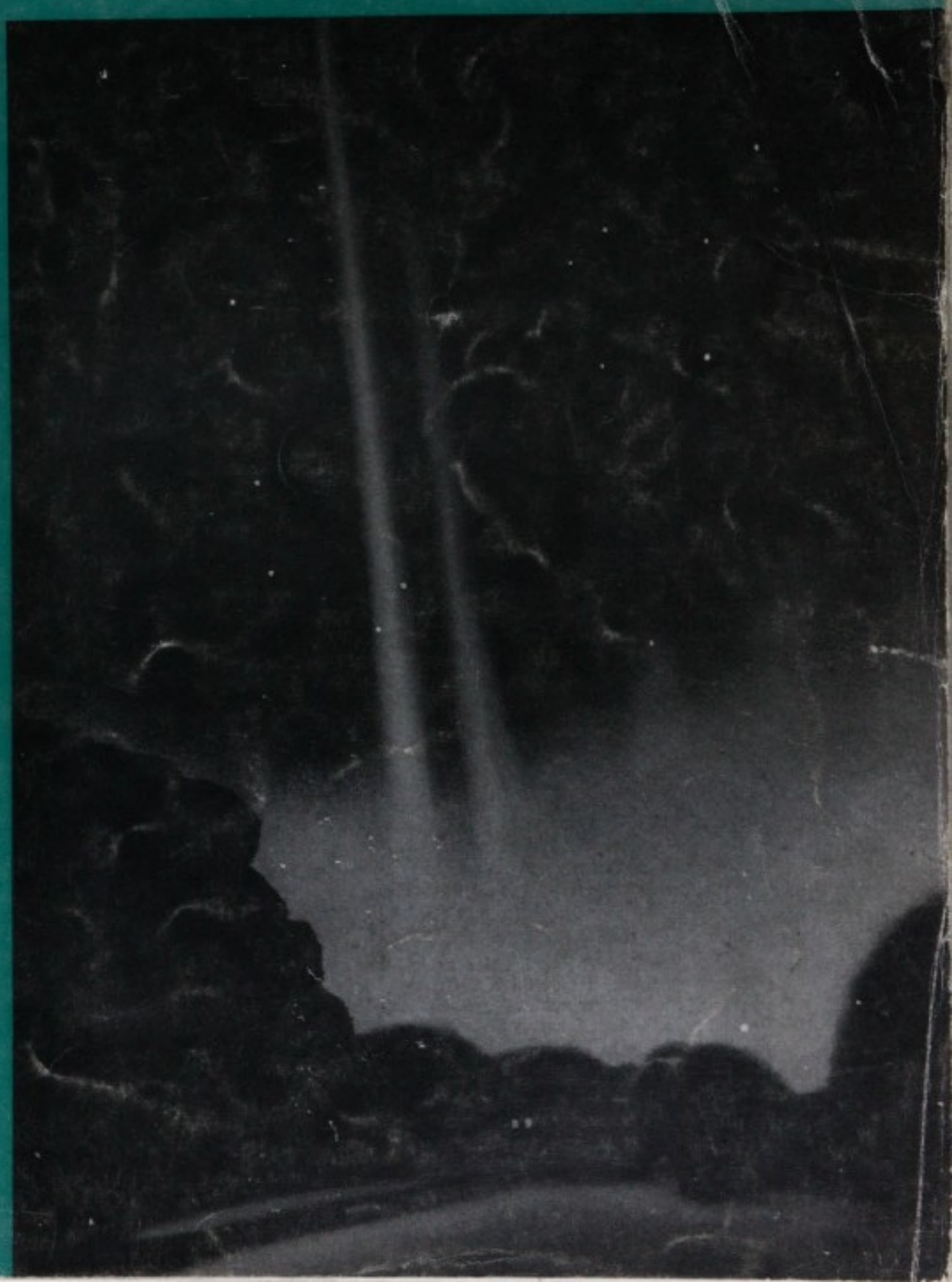

Aurora pastel

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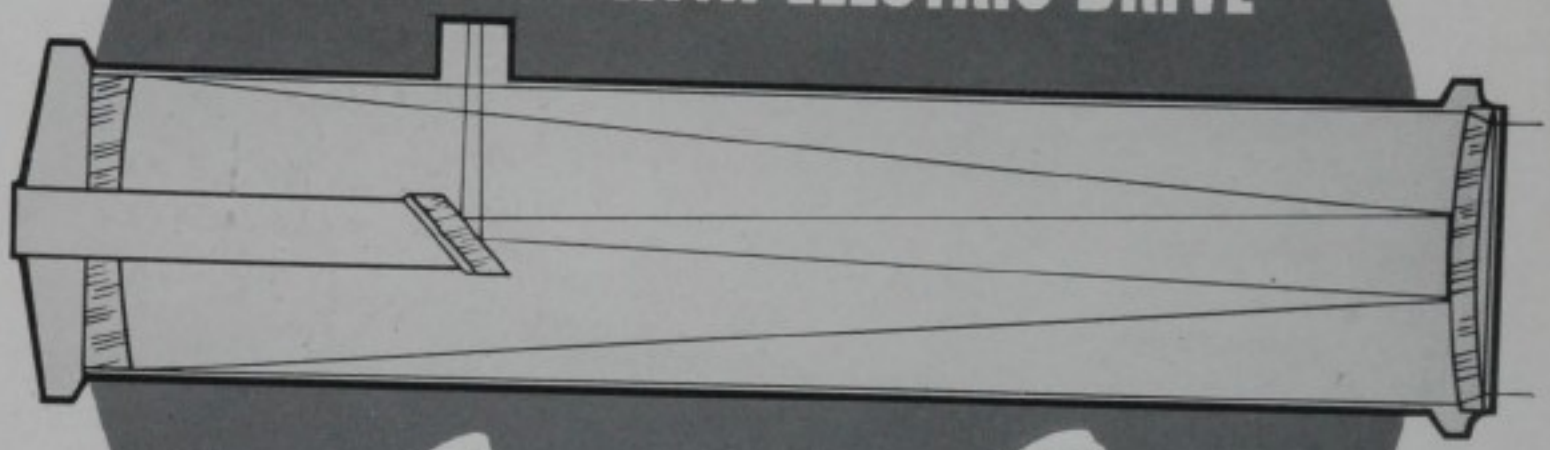

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Sky and TELESCOPE

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Vol. XVII, No. 5 MARCH, 1958

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FEATURE PICTURE: The spiral galaxy NGC 253, photographed with the Radcliffe Observatory 74-inch reflector on November 9-10, 1953. Southern Hemisphere amateurs know this beautiful stellar system as one of the showpieces of the sky. The picture is from the Cape Photographic Atlas of Southern Galaxies, compiled by the Royal Observatory, Cape of Good Hope, Union of South Africa. 225

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An Aurora Pastel

"SUNDAY PAINTERS, as well as observers unfamiliar with photographic processing, may wish to explore the realm of astronomical drawing.

"As the famous astronomical artist of the 19th century, E. Leopold Trouvelot, demontrated so well, pastels are a very satisfactory medium for rendering diffuse objects, such as comets, nebulae, and aurorae. They may be applied rapidly and worked up to give a pleasing luminous effect without appreciable loss of detail. The complete basic outfit for pastel drawing need cost no more than 10 dollars."

These are the words of F. Stuart Smith, of Brookfield, in central Vermont, who made the color sketch of the northern lights appearing on the front cover this month (in black and white). He gives his latitude as 44° 01′ north, longitude 72° 06′ west. The aurora is depicted as it appeared at 9:45 p.m. Eastern standard time on October 21, 1957, when the maximum altitude reached by the bright rays was 48 degrees.

As we are at present in a period of unusually great solar activity, the probability of observing spectacular auroral displays is considerable, even for those who live in the lower latitudes of the United States. Furthermore, about March 1st of each year the sun's north pole is tilted away from the earth its maximum amount (some seven degrees), and sunspots in the south solar hemisphere pass more nearly in line with us. About September 15th, with the sun's north pole tipped toward the earth by the same angle, a similar effect occurs for the northern hemisphere of the sun.

Around these two times of year, therefore, the earth is more apt to intercept fast-moving streams of charged particles sprayed from the sun, such as are responsible for auroral storms. As L. Harang points out in his book, *The Aurorae*, northern lights tend to occur most frequently in March and September, for observers in moderate latitudes. In the polar regions, however, where aurorae are seen on nearly all clear nights, this yearly variation is less apparent. The same two months are also the times when strong geomagnetic storms are commonest, for the same geometrical reason involving the location of active zones on the apparent disk of the sun.

Amateurs are reminded of the need for detailed visual observations as part of the special aurora program of the International Geophysical Year. Full details were given in our May issue last year (page 327), and official reporting forms can be obtained from the IGY Auroral Data Center, Rockefeller Hall, Cornell University, Ithaca, N. Y.

Irregularities in the Earth's Rotation — I

T. GOLD, *Harvard College Observatory*

THE EARTH rotates very smoothly and steadily, and one might think that there is nothing to be investigated. As a timekeeper, the rotation is superb, and only in the last decade have the most refined clocks been able to achieve a precision that surpasses the earth's. As a stable platform for observation of the heavens, the earth does not give us much cause for complaint, and we can use instruments of very high accuracy without being disturbed by any wobble.

The axis of rotation points toward a certain place in the heavens, and we know and understand how this direction sweeps out a cone of about 23½ degrees radius every 26,000 years. This is due to the spinning earth bulging a little at the equator, so the gravitational attractions of the moon and sun are thus applied to a not-quite-spherical earth. A torque is produced in the sense of bringing the plane of the equator toward the lines joining the earth to the sun and moon, but the earth responds to this like a spinning top, moving always at right angles to the applied force. The result is the motion of *precession*.

As the directions toward the sun and the moon change, the torque on the earth varies a little, and consequently the precessional motion is not quite uniform. The slight superposed wobble is called *nutation*.

Now we must be quite clear about the following point. Precession and nutation do not affect the direction of the earth's axis relative to the solid earth itself, but we notice them merely as a change in the aspect of the heavens. The location on the earth's surface of the geographical North Pole — where the apparent center of rotation of the heavens is seen in the zenith — is not affected, but a different point in the heavens is in this center at different times.

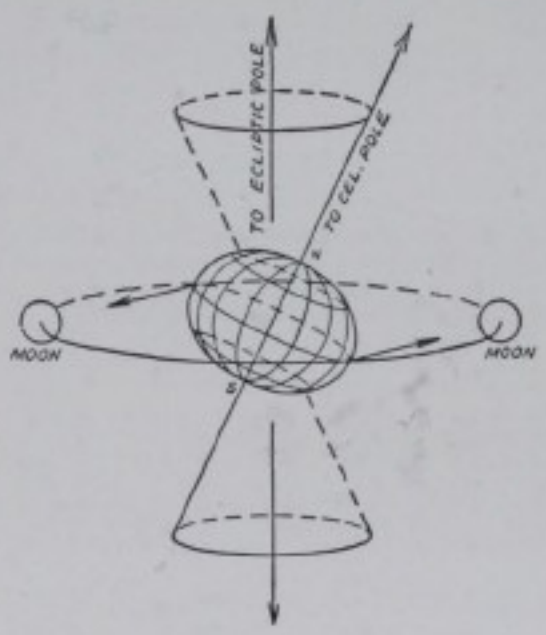
Now what happens when we use still more refined measurements? Is the earth quite so perfect? Astronomers have looked very closely, and they have found an irregularity in almost every quantity that can be measured. The period of rotation — the length of day — varies a little, and clocks that can keep time to better than 1/1,000 of a second per day can show up the effect. But it is hard to know when the earth has completed exactly one rotation. Through our unsteady atmosphere, astronomical observations over many days are required to define the period to that precision.

Also, the rotational axis has been found to misbehave a little. This time, however, it is a motion of the axis relative to the body of the earth. The position of the poles on the surface of the earth moves around in an erratic way by approximately 12 meters. This shifting has been called the *variation of latitude*, because it results in observing stations on the earth changing their astronomically determined latitudes, which, in fact, is how the effect is observed. A number of observatories pool their measurements of these slight latitude changes to deduce from all of them the wobble of the earth as a whole. We shall discuss this motion again later.

What is causing all these irregularities? What is interfering with the smooth rotation of our planet?

We are almost certain that exterior influences are completely accounted for, and that all the troubles are located in the interior of the earth, on its surface, and in the atmosphere and oceans. Some of these effects have been surveyed by Roger Revelle and Walter Munk, of the University of California, and they have very conveniently subdivided the effects according to the speed with which they take place. We shall follow this scheme and discuss separately the wobble of the axis and the variations of rotation that occur in intervals of the order of one year, of 10 years, of 1,000 years, and finally in all geological time.

The rather erratic wobble of the axis has, in fact, an annual component; therefore, it is reasonable to look for its explanation among seasonal climatic effects. The displacement of material from one longitude to another at an intermediate latitude could be responsible, and Sir Harold Jeffreys has shown that the biggest such displacement is the seasonal shift in air masses toward and away from Siberia. In this case, it is not any dynamical effect of the speed of these air masses that we are concerned with, not the wind stresses exerted on the earth, but merely the change in position of the masses as recorded by the barometer and the resulting alteration in the vertical forces. A polar movement of a few meters is just about the amount that can be accounted for within the earth itself by this means, and the effect cannot result in any measurable wobble of the direction of the rotational axis in space.



Precession is a very slow conical swing of our earth's axis of rotation, caused by the attraction of the moon and sun on the earth's equatorial bulge. From "Astronomy" by R. H. Baker.

The length of day also seems to have an annual variation. A day is about 1/1,000 of a second shorter in our northern autumn than in spring, and this requires quite a different explanation. A shift in air masses from one longitude to another would not be effective for this purpose, except for the small amount of angular momentum actually associated with this transportation. Changes of position of air masses in latitude could in principle be effective, because these masses would then change their contributions to the moment of inertia of the earth. No sufficiently large movements of this sort seem to occur, however, and one is forced to look to other seasonal effects.

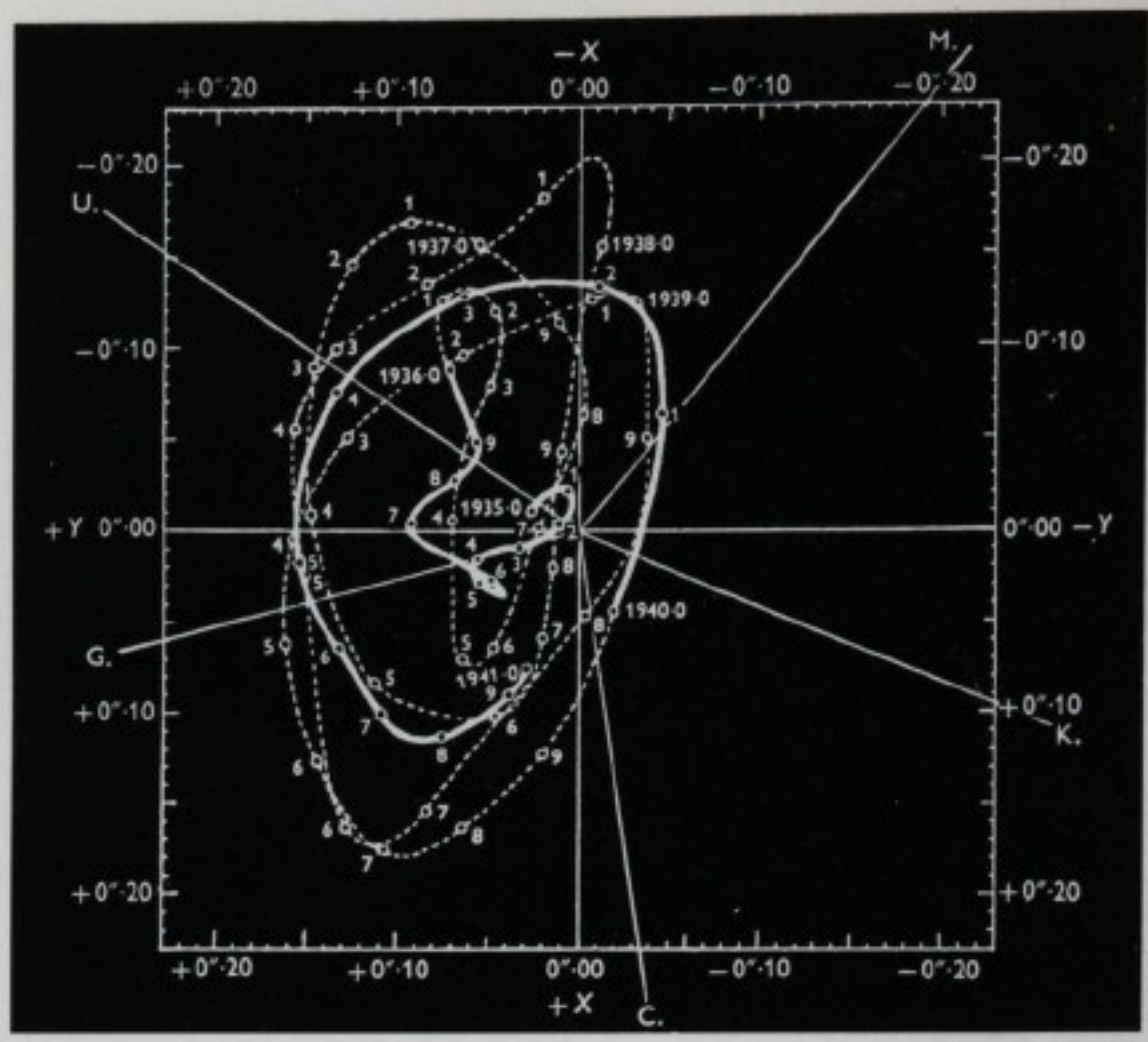
Munk and others have shown that the explanation this time is most likely to be found in wind. A seasonal variation in the angular momentum contained in the whole atmosphere is held responsible, and not the position change of a mass of air. The total angular momentum of the earth and atmosphere together has to stay constant; hence, the motion of the earth shows how much angular momentum has been given to the air.

Let us next consider variations in the length of day with periods of the order of 10 years. It can be determined from astronomical measurements that over such intervals the length of day also fluctuates by something like 1/1,000 of a second. At first sight it might seem that since this effect is no larger than the annual one, no further explanation is required, but this is not so. Variations in the angular momentum contained in the atmosphere repeat themselves quite accurately each year, but they are rhythmic and not cumulative, and over several years could not make the earth go con-

sistently fast or slow by this amount. There are no atmospheric effects that can lead to any cumulative changes in the length of day, and in the oceans neither changes in the state of motion nor changes in level are of the right amount to account for the observations. Fluctuations of the water level on the land as well as other movements there are considered quite inadequate.

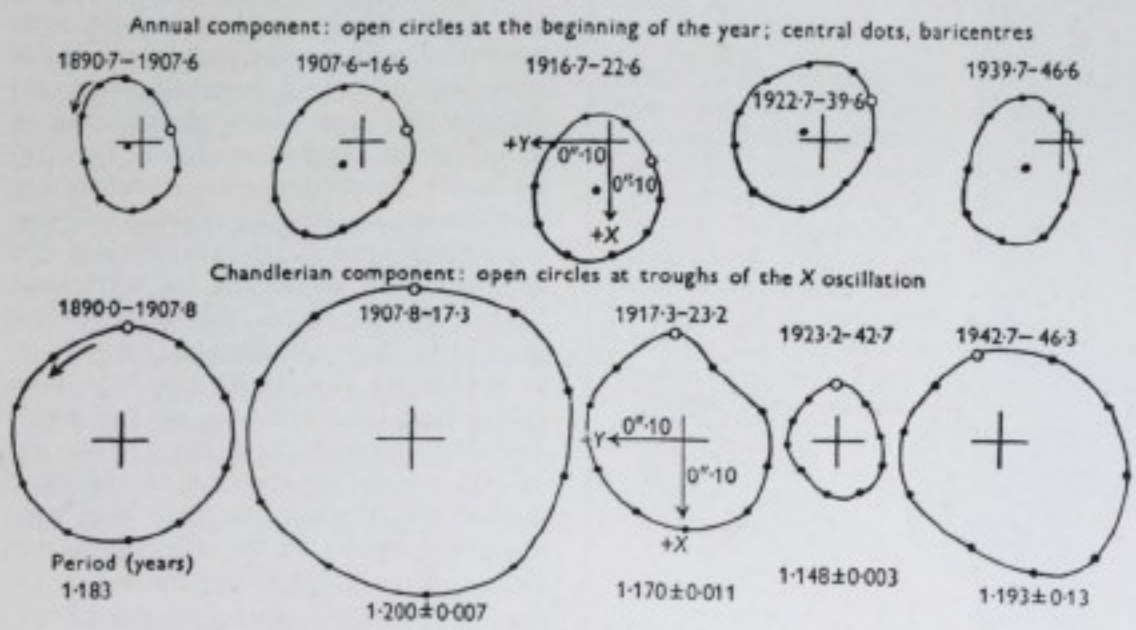
Effects from outside the earth can also be excluded, so it seems that we have here a phenomenon originating in the deep interior of our globe. We may imagine turbulent motion of some kind occurring in the liquid core, and there is even some hope of correlating such an effect with the secular variations in the earth's magnetic field, but these matters are still rather uncertain.

Now let us go back to the wobble of the axis relative to the earth in periods longer than one year. This wandering has a pronounced component with a period of about 14 months, analogous to the action of a rotating top that executes a quick wobble after being disturbed and before settling down again to a steady spin. For the earth this motion is, of course, very much slower, and the amplitude is only between two and five meters of polar shift. Like the annual component, it is almost concealed by irregular effects from time to time, but there is no doubt about its reality or about its identification. It was discovered over 60 years ago by the American astronomer S. C. Chandler, and is called *Chandlerian motion*.



The wanderings of the earth's pole from 1935 to 1940 were within the area of half a tennis court. Pole locations, starting near the center, are shown at 1/10-year intervals, as determined by five stations around the world near latitude 39° north. Radial lines marked with station initials show the directions from the North Pole to five latitude observatories: Gaithersburg, Maryland; Ukiah, California; Mizusawa, Japan; Kitab, Turkestan; and Carloforte, Sardinia.

It is not certain whether the cause of this polar movement can be found entirely in atmospheric effects or whether the core of the earth also plays a part. One suspects that it might, because the internal disturbances giving rise to the variations in the length of day would have to be quite accurately symmetrical around the earth's axis if they were to avoid making a significant contribution to the wobble; but in this case we cannot be sure, because the atmospheric effects by themselves are nearly large enough to account for the phenomenon. Chandlerian motion is very important for the investigation of mechanical properties of the earth, and we will come back to it later.



In this diagram, T. Nicolini has analyzed variation-of-latitude observations of 1890 to 1946, separating the annual component of the polar motion from the 14-month Chandlerian component, for five time intervals. The Chandlerian period, cited in years, is in itself variable. Both diagrams on this page are based on the work of the International Latitude Service, and are reproduced from the "Transactions" of the International Astronomical Union.

For the longer periods of about 10 years, the *mean* position of the pole may change by something like three meters. At the present time the effects of the last ice age are still diminishing, and the most significant melting of ice occurs in Greenland. The water flows into the seas and raises the ocean level, but as Greenland is not on the pole and the oceans are unevenly distributed over the earth, this all results in an unsymmetrical shift of mass, and therefore a change in the direction of the axis of rotation relative to the body of the earth. The astronomical measurements are not very definite in this case, but are in quite good agreement with the shift that would be expected from the known rate of melting.

Astronomical observations made several centuries ago were so rough that they do not permit us to gain any definite knowledge about a possible drift in the location of the rotational axis. We would not know if it had moved by 300 meters in 1,000 years.

We are more fortunate, however, in the variations of the length of day, for there the positions of the tracks of ancient solar eclipses provide a clue. It seems that the day's length has varied by about 1/100 of a second in the course of the last 1,000 or 2,000 years. Changes in sea level have undoubtedly occurred in these

intervals and would produce effects about this large; but there are three other possible sources of disturbance that may be responsible and that are best discussed in connection with the changes in the rotation speed that may have occurred in geological times.

The friction of the ocean tides used to be considered the only effect that could change the speed of rotation over long periods. What happens is that the moon attracts the earth, which is therefore not quite round but has tidal bulges. The moon's gravitational attraction and the centrifugal force of the earth revolving around the common center of gravity of the system would raise two bulges, one facing directly toward and one away from the moon, if the ocean water moved entirely without friction.

A bulge so aligned would have no significant effect on the motion of the earth and the moon. But because of friction in the oceans, the bulge gets dragged around a little and becomes slightly misaligned. The attraction by the moon is a little greater on the nearer protuberance than on the farther one, however, and this causes a torque to be applied to the earth. This is in the sense of slowing down the motion, and the torque is communicated to the solid earth from the water through the action of just the very friction we are discussing.

Of course, there is in turn an action on the moon. It feels the attraction of the revolving tidal bulge, and this gives it a component of force along its orbital motion. Angular momentum is transferred from the rotation of the earth to the orbital motion of the moon. Thus the moon should be gradually receding, and the earth's rotation should be slowing down.

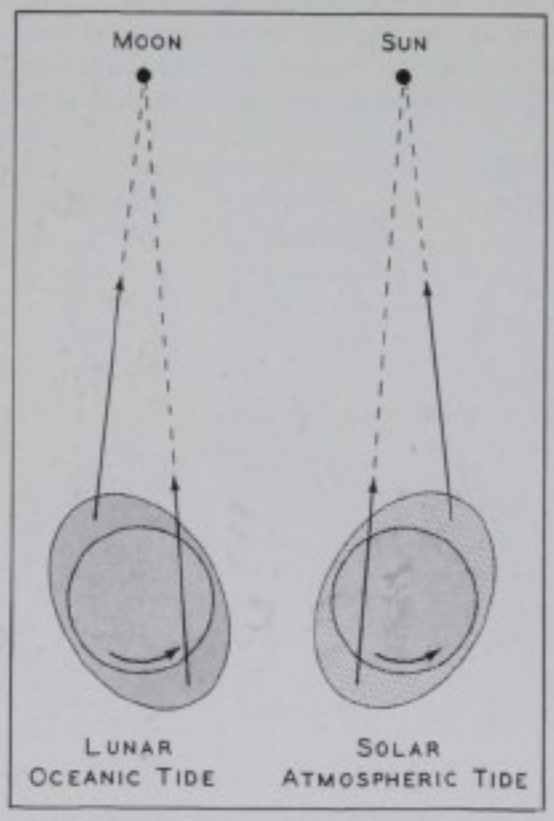
When it comes to estimating the rate of this process over long periods, there is great uncertainty. Jeffreys and G. I. Taylor have shown that most of the friction occurs in just a few suitable shallow seas — the Bering Strait in particular. The main ocean basins themselves have a negligible effect in all geological time. We have no way of estimating how often in the past configurations of the earth's surface features a chance effect like that of the Bering Strait will have arisen. All that one can really say is that it would not be unreasonable to expect tidal friction to have had a large effect in shortening the day during geological times.

Recently, the discussion has widened to include two other effects. First, it has been suggested by H. Urey that the process of formation of a dense liquid core in the earth may still be going on, dense liquid continuing to settle out from the surrounding mantle. This would decrease the moment of inertia of the earth and speed up the rotation. Calculating back on the assumption that this was the only effect, we estimate that before any of the liquid core had settled out the earth would have taken something like 30 hours to turn around. Just when in the history of the earth the settling out of its dense core did occur is, of course, not known.

The other effect now to be included in our discussion is a proposal by E. R. R. Holmberg. He suggested that the atmospheric tide raised by the sun may have an important effect on the earth's rotation. This tide has been known for some time, and can best be measured by a barometer in equatorial latitudes. It is peculiarly large, the barometric effect being much bigger than one would calculate for an atmospheric equilibrium tide. It was necessary to explain this by a coincidence of the present rotation speed of the earth with a natural resonance period of the atmosphere.

A rather remarkable chance, it was thought, that this resonance period and the earth's rotation period should be equal to within less than one part in 200. Even more mysteriously, the phase of this atmospheric tide is not such as to slow down the rotation of the earth and dissipate energy (as does the oceanic tide), but, unexpectedly, it is in the opposite sense — it must be speeding up the earth and using energy to do so.

For many years this anomaly has been a puzzle, but now Holmberg concludes that the extra energy coming out of the atmosphere can only be supplied by solar heating. The solar atmospheric tide and the solar heating of the atmosphere must, after all, necessarily stay in step with one another. The atmospheric gas is simultaneously subjected to a pressure variation and a temperature variation. This is the basic requirement for a heat engine. One compresses a gas, and while it is compressed supplies it with heat; then one lets it expand and cool. Such a cycle can be repeated, and each time some mechanical energy will be liberated. Holmberg has calculated that the atmospheric heat engine, driven by the sun, can adequately account for the anomalous phase of this tide and supply the energy that is required.



Since oceanic tidal bulges are dragged ahead by the rotating earth, the moon's net attraction on them tends to brake the earth's spin, but a solar atmospheric tide can act to speed the rotation.

But his argument goes further. The magnitude of the pressure cycle to which the atmosphere is subjected will change greatly as resonance is approached. The efficiency of a heat engine increases as the compression goes up, and more energy becomes available near resonance than far from it. This, Holmberg says, is just what we need to explain the curious coincidence of the periods. The earth would first slow down by ordinary tidal friction, its rotation speed coming slowly into the range of the resonance; the atmospheric tide would then have increased in amplitude, allowing the heat-engine effect to take place. The atmospheric tide would counteract further slowing down. The atmospheric resonance period is thus a barrier at which the slowing-down process should have halted, and it is not surprising that we now find the earth rotating at just the right speed.

At the present time, oceanic friction seems to be somewhat greater than the opposing atmospheric effect, but this does not destroy Holmberg's theory. It merely means that, perhaps for only as long as the Bering Straits last, we will be drifting a little closer to the resonance peak and the atmospheric effect will be increasing. In intervals which from this point of view are very short, the particular shallow seas that are now responsible may have disappeared, and the long-term oceanic friction may well be below the strength of the maximum atmospheric effect.

If Holmberg is right, perhaps the rotation speed of the earth may have been controlled over a large part of geological time, and we shall have to know the changes that have taken place in the atmosphere in order to learn how its resonance frequency, and therefore the earth's rotation, may have varied. If during all this time lunar oceanic tidal friction has been significant but not dominant, then the moon will have receded gradually. But the angular momentum it needed for this would not have been taken from the rotation of the earth. Instead, it would have come from the orbital angular momentum of the earth around the sun, for this must have been decreased slightly by the tidal interaction that gave an accelerating torque to the earth. The earth's spin and the complicated double tidal effect would then merely be an intermediary in transferring angular momentum from the earth's orbit about the sun to the moon's orbit around the earth.

(To be continued)

Getting Acquainted with Astronomy

THINGS TO OBSERVE IN THE SKY — I, *by Edward G. Oravec*

SINCE earliest times men have gazed at the heavens in wonder and awe. Today, with our scientific instruments and tools, we have begun to understand the workings of the universe about us. But although we may read books, view photographs taken through large observatory telescopes, attend lectures, or construct our own instruments, the full appeal of astronomy is not felt until we study the heavens ourselves.

The best observing can be carried on in the clear air of the country, where the beauty of the night sky is unveiled and the viewer is literally overwhelmed by the seeming complexity of the myriad points of light above. And even if you live in the bright and smoky city, there is much to be seen.

By far the best course is to begin with simple constellation study and gradually take up more complex observing with instruments. It is true that binoculars or a telescope are desirable aids in most observations, and some type of instrument should be eventually obtained by every amateur, either through purchase, loan, or construction. But some amateurs begin immediately with a telescope, ranging over the sky with it, pausing at whatever attracts their attention. Failing to follow a system, they often become discouraged and put the telescope away in the attic, disappointed in what they have seen and, perhaps, losing their interest in astronomy. This need not be so.

Constellation Study

On most dark nights, two or three thousand stars are visible to the unaided eye, and to locate any particular object of interest may be difficult with the portable telescopes used by most amateurs. A knowledge of the constellations is of great value to all observers, for it aids us in knowing when and where to look for planets, clusters, double stars, and the like.

There are 88 constellations in the entire sky. They occupy sky areas of wide variety in size and shape; some of them are brilliant figures of striking outline, as are Orion and the Scorpion, and others are dim, with difficult patterns, as is Camelopardalis, a little-known group close to the north pole of the sky.

It is well to become familiar, early in your study of the heavens, with the zodi-

Corona Borealis is a favorite among the spring constellations. Its neat, compact circlet of stars is at the top of this photograph by Luc Secretan.

acal constellations. These are the star groups that lie along the ecliptic, which is the sun's apparent path around the sky each year. There are 12 principal constellations in the zodiac, the region within which the moon and planets generally confine their travels as they cross the sky. If an observer knows the bright stars of the zodiac, he will have little trouble identifying the naked-eye planets, Mercury, Venus, Mars, Jupiter, and Saturn, wherever they may appear.

Constellation study might well start with the more outstanding groups visible at a particular season, then those in the zodiac, followed by others of less prominence. As the months pass, the stars drift westward, and in the east new groups appear, providing an ever-changing panorama that adds to the enjoyment of knowing the heavens. An ambitious student may, however, observe the evening groups of other seasons, though not for the entire year, by staying up all night. Only the region of the sky near the sun is unobservable, until the sun has moved.

There is another kind of limitation on how much sky one can see, and this can be overcome, for observers in mid-northern latitudes, only by a journey south. For example, a resident of Chicago, some 42 degrees north of the equator, cannot see the part of the sky that is within 42 degrees of the south celestial pole; to a Jacksonville, Florida, amateur, however, the unobservable region is only 30 degrees in radius, corresponding to the latitude of that city.

Some of the brightest parts of the Milky Way, and four or five of the 1st-magnitude stars, are thus hidden from observers in parts of the United States. But those as far north as latitude 38° can see the second brightest star, Canopus, low in the south and somewhat dimmed as it crosses the meridian. From latitude 30° north, about 70 constellations appear in whole or in part in the course of a year. The Southern Cross is among these, but to see it completely one must be as far south as Key West in Florida.

There are numerous books, devices, and charts that will aid in making order

On spring evenings in the Northern Hemisphere, the constellation of Ursa Major dominates the sky near the zenith. To the south of it is Leo, one of the easiest configurations to identify in the heavens. When facing north, hold this chart upside down (south upward).

EDITOR'S NOTE: This new department of *Sky and Telescope* will contain introductory material on all phases of astronomy, particularly designed to assist amateurs in the understanding of this science. Mr. Oravec's article, and much of the material scheduled for future publication, was originally prepared for an observing manual of the Astronomical League. At its Kansas City meeting, the league executive council dropped its manual publication plans.

Name	Pronunciation	Genitive	Pronunciation	Meaning
Andromeda	ăn-drŏm'ē-dȧ	Andromedae	ăn-drŏm'ē-dē	Andromeda
Antlia	ănt'lĭ-ȧ	Antliae	ănt'lĭ-ē	(air) pump*
Apus	ā'pŭs	Apodis	ăp'ō-dĭs	bird of paradise
Aquarius	ȧ-kwâr'ĭ-ŭs	Aquarii	ȧ-kwâr'ĭ-ī	water carrier
Aquila	ăk'wĭ-lȧ	Aquilae	ăk'wĭ-lē	eagle
Ara	ā'rȧ	Arae	ā'rē	altar
Aries	ā'rĭ-ēz	Arietis	ȧ-rī'ē-tĭs	ram
Auriga	ô-rī'gȧ	Aurigae	ô-rī'jē	charioteer
Boötes	bō-ō'tēz	Boötis	bō-ō'tĭs	herdsman
Caelum	sē'lŭm	Caeli	sē'lī	graving tool
Camelopardalis	kȧ-mĕl'ō-pär'dȧ-lĭs	Camelopardalis	kȧ-mĕl'ō-pär'dȧ-lĭs	giraffe
Cancer	kăn'sẽr	Cancri	kăng'krī	crab
Canes Venatici	kā'nēz vē-năt'ĭ-sī	Canum Venaticorum	kā'nŭm vē-năt'ĭ-kō'rŭm	hunting dogs
Canis Major	kā'nĭs mā'jẽr	Canis Majoris	kā'nĭs mā-jō'rĭs	larger dog
Canis Minor	kā'nĭs mī'nẽr	Canis Minoris	kā'nĭs mĭ-nō'rĭs	smaller dog
Capricornus	kăp'rĭ-kôr'nŭs	Capricorni	kăp'rĭ-kẽr'nī	horned goat
Carina	kȧ-rī'nȧ	Carinae	kȧ-rī'nē	keel
Cassiopeia	kăs'ĭ-ō-pē'yȧ	Cassiopeiae	kăs'ĭ-ō-pē'yē	Cassiopeia
Centaurus	sẽn-tô'rŭs	Centauri	sẽn-tô'rī	centaur
Cepheus	sē'fūs	Cephei	sē'fē-ī	Cepheus
Cetus	sē'tŭs	Ceti	sē'tī	whale
Chamaeleon	kȧ-mē'lē-ŭn	Chamaeleontis	kȧ-mē'lē-ŏn'tĭs	chameleon
Circinus	sûr'sĭ-nŭs	Circini	sûr'sĭ-nī	pair of compasses
Columba	kō-lŭm'bȧ	Columbae	kō-lŭm'bē	dove
Coma Berenices	kō'mȧ bĕr'ē-nī'sēz	Comae Berenices	kō'mē bĕr'ē-nī'sēz	Berenice's hair
Corona Australis	kō-rō'nȧ ôs-trā'lĭs	Coronae Australis	kō-rō'nē ôs-trā'lĭs	southern crown
Corona Borealis	kō-rō'nȧ bō'rē-ă'lĭs	Coronae Borealis	kō-rō'nē bō'rē-ă'lĭs	northern crown
Corvus	kôr'vŭs	Corvi	kôr'vī	crow
Crater	krā'tẽr	Crateris	krā-tē'rĭs	cup
Crux	krŭks	Crucis	krōō'sĭs	cross
Cygnus	sĭg'nŭs	Cygni	sĭg'nī	swan
Delphinus	dĕl-fī'nŭs	Delphini	dĕl-fī'nī	dolphin
Dorado	dō-rā'dō	Doradus	dō-rā'dŭs	dorado[a fish]
Draco	drā'kō	Draconis	drā-kō'nĭs	dragon
Equuleus	ē-kwōō'lē-ŭs	Equulei	ē-kwōō'lē-ī	colt
Eridanus	ē-rĭd'ȧ-nŭs	Eridani	ē-rĭd'ȧ-nī	Eridanus [a river]
Fornax	fôr'năks	Fornacis	fôr-nā'sĭs	furnace
Gemini	jĕm'ĭ-nī	Geminorum	jĕm'ĭ-nō'rŭm	twins
Grus	grŭs	Gruis	grōō'ĭs	crane
Hercules	hûr'kŭ-lēz	Herculis	hûr'kŭ-lĭs	Hercules
Horologium	hŏr'ō-lō'jĭ-ŭm	Horologii	hŏr'ō-lō'jĭ-ī	clock
Hydra	hī'drȧ	Hydrae	hī'drē	water monster
Hydrus	hī'drŭs	Hydri	hī'drī	water snake
Indus	ĭn'dŭs	Indi	ĭn'dī	Indian
Lacerta	lȧ-sûr'tȧ	Lacertae	lȧ-sûr'tē	lizard
Leo	lē'ō	Leonis	lē-ō'nĭs	lion
Leo Minor	lē'ō mī'nẽr	Leonis Minoris	lē-ō'nĭs mĭ-nō'rĭs	smaller lion
Lepus	lē'pŭs	Leporis	lĕp'ō-rĭs	hare
Libra	lī'brȧ	Librae	lī'brē	balance
Lupus	lū'pŭs	Lupi	lū'pī	wolf
Lynx	lĭngks	Lyncis	lĭn'sĭs	lynx
Lyra	lī'rȧ	Lyrae	lī'rē	lyre
Mensa	mĕn'sȧ	Mensae	mĕn'sē	table (mountain)
Microscopium	mī'krō-skō'pĭ-ŭm	Microscopii	mī'krō-skō'pĭ-ī	microscope
Monoceros	mō-nŏs'ẽr-ōs	Monocerotis	mō-nŏs'ẽr-ō'tĭs	unicorn
Musca	mŭs'kȧ	Muscae	mŭs'sē	fly
Norma	nôr'mȧ	Normae	nôr'mē	square (and rule)
Octans	ŏk'tănz	Octantis	ŏk-tăn'tĭs	octant
Ophiuchus	ŏf'ĭ-ū'kŭs	Ophiuchi	ŏf'ĭ-ū'kī	serpent holder
Orion	ō-rī'ŏn	Orionis	ō'rĭ-ō'nĭs	Orion
Pavo	pā'vō	Pavonis	pă-vō'nĭs	peacock
Pegasus	pĕg'ȧ-sŭs	Pegasi	pĕg'ă-sī	Pegasus [winged horse]
Perseus	pûr'sŭs	Persei	pûr'sē-ī	Perseus
Phoenix	fē'nĭks	Phoenicis	fē-nī'sĭs	phoenix
Pictor	pĭk'tẽr	Pictoris	pĭk-tō'rĭs	painter's (easel)
Pisces	pĭs'ēz	Piscium	pĭsh'ĭ-ŭm	fishes
Piscis Austrinus	pĭs'ĭs ôs-trī'nŭs	Piscis Austrini	pĭs'ĭs ôs-trī'nī	southern fish
Puppis	pŭp'ĭs	Puppis	pŭp'ĭs	stern
Pyxis	pĭk'sĭs	Pyxidis	pĭk'sĭ-dĭs	mariner's compass
Reticulum	rē-tĭk'ŭ-lŭm	Reticuli	rē-tĭk'ŭ-lī	net
Sagitta	sȧ-jĭt'ȧ	Sagittae	sȧ-jĭt'ē	arrow
Sagittarius	săj'ĭ-tā'rĭ-ŭs	Sagittarii	săj'ĭ-tā'rĭ-ī	archer
Scorpius	skôr'pĭ-ŭs	Scorpii	skôr'pĭ-ī	scorpion
Sculptor	skŭlp'tẽr	Sculptoris	skŭlp-tō'rĭs	sculptor's (workshop)
Scutum	skū'tŭm	Scuti	skū'tī	shield
Serpens	sûr'pĕnz	Serpentis	sẽr-pĕn'tĭs	serpent
Sextans	sĕks'tănz	Sextantis	sĕks-tăn'tĭs	sextant
Taurus	tô'rŭs	Tauri	tô'rī	bull
Telescopium	tĕl'ē-skō'pĭ-ŭm	Telescopii	tĕl'ē-skō'pĭ-ī	telescope
Triangulum	trī-ăng'gŭ-lŭm	Trianguli	trī-ăng'gŭ-lī	triangle
Triangulum Australe	trī-ăng'gŭ-lŭm ôs-trā'lē	Trianguli Australis	trī-ăng'gŭ-lī ôs-trā'lĭs	southern triangle
Tucana	tŭ-kā'nȧ	Tucanae	tŭ-kā'nē	toucan
Ursa Major	ûr'sȧ mā'jẽr	Ursae Majoris	ûr'sē mă-jō'rĭs	larger bear
Ursa Minor	ûr'sȧ mī'nẽr	Ursae Minoris	ûr'sē mĭ-nō'rĭs	smaller bear
Vela	vē'lȧ	Velorum	vē-lō'rŭm	sails
Virgo	vûr'gō	Virginis	vûr'jĭ-nĭs	virgin
Volans	vō'lănz	Volantis	vō-lăn'tĭs	flying (fish)
Vulpecula	vŭl-pĕk'ŭ-lȧ	Vulpeculae	vŭl-pĕk'ŭ-lē	little fox

*Present day constellation names are in some cases abbreviations of former more complete names. The parts within the parentheses are the meanings of deleted words.

The constellations are listed with the pronunciations recommended by a committee of the American Astronomical Society in 1942. The genitive form is used when the constellation name is part of a star designation, as in Alpha Lyrae or 61 Cygni. This and the chart opposite appeared in "Sky and Telescope" for June, 1943.

out of the apparent chaos of stars. In the *Field Book of the Skies*, by William Tyler Olcott (revised in 1955 by Mayall and Mayall), each constellation is described individually and the chief objects of observing interest within its area are pointed out. Other sections of that book are devoted to the moon, planets, and similar subjects, making it a valuable aid to the amateur astronomer, both beginner and more experienced. For general detailed star maps, Norton's *Star Atlas*

and the Skalnate Pleso *Atlas of the Heavens* are among the best.

One very useful device is a planisphere, a revolving map of the heavens that can be set to represent the visible sky at any time for any day of the year. To use a planisphere, one must know roughly where north is. Then, by orienting it properly and comparing the figures of the stars with the patterns on the map, it is possible to gain a working acquaintance with the constellations. One defect of a planisphere, however, is the distortion of star patterns far from the celestial pole; another flaw is the varying scale of angular distance along the horizon.

A simple, yet effective planisphere is called the Star Explorer; it may be purchased from the Junior Astronomy Club, Brooklyn Public Library, Grand Army Plaza, Brooklyn 38, N. Y. Others, more accurately plotted and containing more information, are available from planetarium book counters and from book stores. The monthly star maps carried in *Sky and Telescope* are helpful in showing the current locations of star groups, the Milky Way, and the planets.

Some students like to learn their constellations from star globes, on which the heavens can be represented without the distortion that is unavoidable in flat maps and charts. But most globes show the sky as seen from the outside looking in, which results in a reversal of left and right. Care must be taken to allow for this when comparing the figures on a globe with their actual celestial counterparts.

A student of the constellations will soon get to know such important astronomical terms as magnitude, right ascension and declination, and hour angle. Most books on constellations and observing introduce and explain terms associated with observational astronomy. The beginner is urged to learn about these as soon as possible, for they will aid him greatly in whatever kinds of observing he may want to do. This knowledge is a useful by-product of constellation study.

(To be continued)

KEY TO PRONUNCIATION

a

ā as in āle, fāte, nāker, profāne.
â as in châotic, fâtality, grâdation, vâcation.
ă as in băck, hăt, răndom, sănd, tăp.
ȧ as in ȧbhor, ȧccount, firȧl, sylvȧn, vocȧnt.
ä as in ärk, gräss, läst, päth, shäft.
ạ as in ạbide, ạround, diạdem, ideạ, sofạ.
â as in câre, compâre, thâre, pârent, shâre.
ă as in ălms, ărm, făr, făther, pălm.
au as in aught, caught, haul, taut (= ô).

e

ē as in bē, concrēte, dēviate, ēve, mēter.
ê as in crêate, dêlineate, êpitome, êvade.
ĕ as in ĕnd, ĕrror, fĕrry, pĕt, tĕn.
ẹ as in angẹl, camẹl, gospẹl, jewẹl, novẹl.
ẽ as in lovẽr, makẽr, pẽrform, readẽr.

i

ī as in bīnd, child, īce, slight, time.
ĭ as in bĭt, habĭt, humĭd, lĭll, pĭt.
i as in animal, charity, possible, venality.

o

ō as in bōne, mōtion, nōte, ōld, ōver.
ȯ as in anatȯmy, biolȯgy, cȯhesion, ȯbey, pȯtato.
ŏ as in nŏt, lŏck, nŏt, ŏdd, pŏd, prŏper.
o̅ as in co̅nform, co̅nnect, co̅ncur, o̅ffend, co̅ncess.
ô as in shôr, bôrder, lôrd, ôrb, ôrder.
o͞o as in fo͞od, fo͞ol, mo͞on, sto͞op, to͞ol.
o͝o as in b͝ook, sh͝ook, f͝oot, g͝ood, w͝ood.
ou as in about, house, out, pout.

u

ū as in ūnite, cūbe, dūty, lūte, nūde, tūbe.
ŭ as in ŭnite, graduate, insular, sŭpreme, ŭnite.
ŭ as in sŭn, tŭb, ŭnder, ŭp, ŭncer.
u̅ as in stru̅ggle, dastu̅rd, ru̅bmit, volu̅ntary.
û as in bûrn, bûrl, stûrt, ûrge, ûrn.

GREEK ALPHABET

	Name	Pronunciation		Name	Pronunciation
α	Alpha	ăl'fȧ	ν	Nu	nū
β	Beta	bā'tȧ	ξ	Xi	zī
γ	Gamma	găm'ȧ	ο	Omicron	ŏm'ĭ-krŏn
δ	Delta	dĕl'tȧ	π	Pi	pī
ε	Epsilon	ĕp'sĭ-lŏn	ρ	Rho	rō
ζ	Zeta	zā'tȧ	σ	Sigma	sĭg'mȧ
η	Eta	ā'tȧ	τ	Tau	tou
θ	Theta	thā'tȧ	υ	Upsilon	ŭp'sĭ-lŏn
ι	Iota	ī-ō'tȧ	φ	Phi	fī
κ	Kappa	kăp'ȧ	χ	Chi	kī
λ	Lambda	lăm'dȧ	ψ	Psi	sī
μ	Mu	mū	ω	Omega	ō-mē'gȧ

PLANETS

Name	Pronunciation	Name	Pronunciation
Mercury	mûr'kū-rĭ	Saturn	sāt'ẽrn
Venus	vē'nu̅s	Uranus	ū'rȧ-nu̅s
Earth	ûrth	Neptune	nĕp'tūn
Mars	mārz	Pluto	plūtō'nĭ
Jupiter	jo͞o'pĭ-tẽr		

FIFTY IMPORTANT SPECIAL STAR NAMES

Name	Pronunciation	Equivalent
Achernar	ā'kẽr-nẽr	α Eridani
Albireo	ăl-bĭr'ē-ō	β Cygni
Alcor	ăl'kôr	80 Ursae Majoris
Alcyone	ăl-sī'ō-nē	η Tauri
Aldebaran	ăl-dĕb'ȧ-rȧn	α Tauri
Algenib	ăl-jē'nĭb	γ Pegasi
Algol	ăl'gŏl	β Persei
Alioth	ăl'ĭ-ŏth	ε Ursae Majoris
Alkaid	ăl-kād'	η Ursae Majoris
Almach	ăl'măk	γ Andromedae
Alphard	ăl'färd	α Hydrae
Alphecca	ăl-fĕk'ȧ	α Coronae Borealis
Alpheratz	ăl-fē'rătz	α Andromedae
Altair	ăl-tār'	α Aquilae
Antares	ăn-tā'rēz	α Scorpii
Arcturus	ärk-tū'rŭs	α Bootis
Bellatrix	bĕ-lā'trĭks	γ Orionis
Betelgeuse	bē'tĕl-jo͞os	α Orionis
Canopus	kȧ-nō'pŭs	α Carinae
Capella	kȧ-pĕl'ȧ	α Aurigae
Castor	kăs'tẽr	α Geminorum
Deneb	dĕn'ĕb	α Cygni
Deneb Kaitos	dĕn'ĕb kā'tŏs	β Ceti
Denebola	dē-nĕb'ō-lȧ	β Leonis
Dubhe	dŭb'ē	α Ursae Majoris
Elnath	ĕl'năth	β Tauri
Fomalhaut	fō'măl-ôt	α Piscis Austrini
Hamal	hăm'ăl	α Arietis
Markab	mär'kăb	α Pegasi
Megrez	mē'grĕz	δ Ursae Majoris
Menkar	mĕn'kär	α Ceti
Merak	mē'răk	β Ursae Majoris
Mira	mī'rȧ	ο Ceti
Mirach	mī'răk	β Andromedae
Mirfak	mĭr'făk	α Persei
Mizar	mī'zär	ζ Ursae Majoris
Phecda	fĕk'dȧ	γ Ursae Majoris
Polaris	pō-lā'rĭs	α Ursae Minoris
Pollux	pŏl'ŭks	β Geminorum
Procyon	prō'sĭ-ŏn	α Canis Minoris
Rasalgethi	răs'ăl-jĕ'thī	α Herculis
Rasalhague	răs'ăl-hā'gwē	α Ophiuchi
Regulus	rĕg'ū-lŭs	α Leonis
Rigel	rī'jĕl	β Orionis
Scheat	shē'ăt	β Pegasi
Schedar	shĕd'ăr	α Cassiopeiae
Sirius	sĭr'ĭ-u̅s	α Canis Majoris
Spica	spī'kȧ	α Virginis
Thuban	thū'băn	α Draconis
Vega	vē'gȧ	α Lyrae

CLUSTERS

Name	Pronunciation	Description
Hyades	hī'ȧ-dēz	Open star cluster in Taurus
Pleiades	plē'yȧ-dēz	Open star cluster in Taurus
Praesepe	prē-sē'pē	Open star cluster in Cancer

Pronunciations of the names of the planets and of some of the brightest and most famous stars are given in this second reproduction from the committee report of the American Astronomical Society.

QUESTIONS... FROM THE S+T MAILBAG

Q. What is local mean time?

A. A clock keeps time at a uniform rate, whereas the sun in the sky moves irregularly, so hours and minutes marked by an ordinary solar timekeeper (such as a sundial) are not of uniform length. Therefore, to match mechanical clocks, we imagine that there is a *mean sun*, a fictitious body that moves eastward during the year along the celestial equator at a uniform rate. The mean sun for any one location keeps local mean time, and when it crosses the local meridian, local mean noon occurs.

Q. What is meant by the term "the sun is slow"?

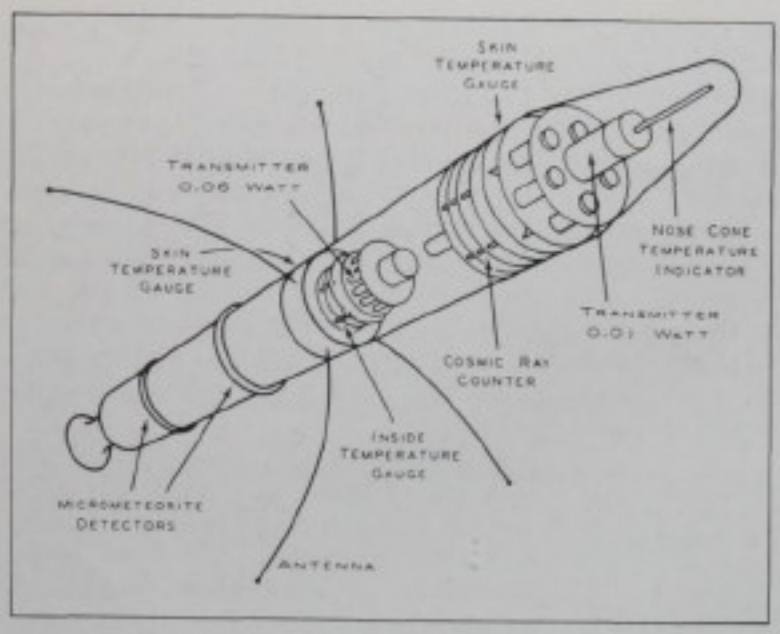
A. This statement compares the real or apparent sun in the sky with the mean sun. The sun is said to be slow when it crosses the meridian later than 12 o'clock local mean time; it is fast when it crosses the meridian before local mean noon. The difference between the two, called the equation of time, is listed in almanacs, + for sun slow and — for sun fast.

Q. How do I find my local mean time?

A. By converting the standard time used in ordinary civil affairs to your local meridian's time. The correction is four minutes for each degree of longitude difference between your meridian and your standard-time meridian, added to the standard time if you are east of the standard meridian, subtracted if you are west. A list of such corrections was given on page 133 of the January issue, with the arithmetic signs being reversed to provide for converting local mean time to standard time.

W. E. S.

More Satellite Talk



Explorer, the first American artificial satellite, contains a number of different kinds of instruments. Its low-power radio transmitter is expected to broadcast for several months, much longer than for any previous satellite flight.

First American Satellite

EARTH gained a new artificial satellite on January 31st, as a large modified Jupiter-C missile rose in a great burst of flame from its launching pad at Cape Canaveral, Florida, at 10:48 p.m. Eastern standard time. Seven minutes later, a pencil-shaped moonlet 80 inches long was in orbit, traveling around the earth in a period just a few minutes short of two hours.

The path of Satellite 1958α is inclined about 34 degrees to the earth's equator. Early calculations at the Naval Research Laboratory placed its perigee over the Northern Hemisphere about 230 miles above the earth's surface, and apogee at 1,600 miles high. Thus, initially "Explorer" had a considerably more elongated orbit than its predecessors, Sputnik I and II, and on each revolution did not penetrate as deeply into the atmosphere. Its lifetime is estimated to be at least a year or two and perhaps as long as 10 years.

When Soviet scientists launched Sputnik II early in November, the U. S. Army was directed to modify the Jupiter-C vehicle to carry aloft a satellite. Most of the development program was carried on by the Army Ballistic Missile Agency, Huntsville, Alabama, and the Jet Propulsion Laboratory at California Institute of Technology. The Explorer success is largely due to the Army's missile expert, Dr. Wernher von Braun, famous for his part in developing the German V-2 rocket.

The four-stage vehicle, nearly 69 feet long over-all, had a first stage 56 feet long and nearly six feet in diameter. The liquid-propellant motor developed some 83,000 pounds of thrust; the missile rose 53 miles before burnout, 150 seconds after takeoff. Then the first stage dropped off, the remaining assembly coasting upward to the apex of its trajectory, attaining level flight about 400 seconds after takeoff. At that time the vehicle was some 400 or 500 miles down range, southeasterly from Cape Canaveral, and about 200 miles high. The solid-propellant second stage, consisting of a cluster of scaled-down Army tactical Sergeant rockets, was then fired, followed by the third stage of similar units. As these rockets fired, they were spinning some 1,000 times a minute around the assembly's longitudinal axis, so that failure of any one of them would not cause the direction of flight to change.

The fourth stage, another Sergeant, was fired after the others had burned out and dropped away, leaving the 31-pound combined satellite (exhausted fourth stage and instrument casing). The total acceleration was great enough to carry it to a maximum distance roughly two-fifths the earth's radius out into space. Assuming perigee at 230 miles and apogee at 1,600, the semimajor axis of the orbit was some 4,880 miles and the eccentricity about 14 per cent. For a revolution period of 115 minutes, the average orbital velocity was nearly 16,000 miles an hour, changing from about 18,500 at perigee to about 14,000 at apogee.

In the 7½-pound steel instrument case is a payload of about 11 pounds of instruments designed to gather information on micrometeorite impacts, cosmic rays, skin temperature, and internal temperature of the satellite. On the first revolution, three or four of the 12 exterior erosion gauges were broken, but it was uncertain whether this was from collisions with meteoritic particles or from vibration at takeoff. The cosmic ray counts, with a small Geiger counter, were about 30 per minute, in agreement with expectations. The interior temperature was +30° centigrade a few hours after launching.

The data gathered by these instruments are radioed to the ground by two transmitters, the stronger working at 108.03 megacycles. It has a power of 0.06 watt and an expected operating life of two to three weeks, whereas the other transmitter, at 108.00 megacycles, may operate for two or three months at 0.01 watt.

Amateur radio operators, commercial monitoring stations, and the Minitrack satellite-tracking network have all picked up the Explorer radio signals. Nearly all available orbital information has come from the Naval Research Laboratory, which has the over-all responsibility for the radio tracking of artificial satellites.

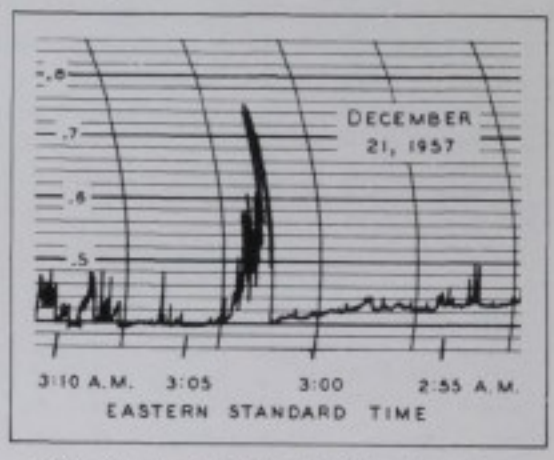
For visual observers, the American moonlet is a much more difficult object to detect than either of the Russian carrier rockets. Satellite 1958α is fainter because of its smaller size and greater height; also, its low orbital inclination is unfavorable to watchers in the northern United States.

The first definite sighting by a MOONWATCH team was achieved by the station at Alamogordo, New Mexico, on February 1st at 7:45 p.m. Mountain standard time. There 19 telescopes were arranged along the meridian. P. H. Grubb, watching about 10 degrees north of the zenith, was the first to see a slowly moving 8th-magnitude point of light, which was confirmed by three other members of the team. A second Alamogordo observation was secured the next night at 8:46 p.m. MST, according to group leader E. P. Martz, Jr.

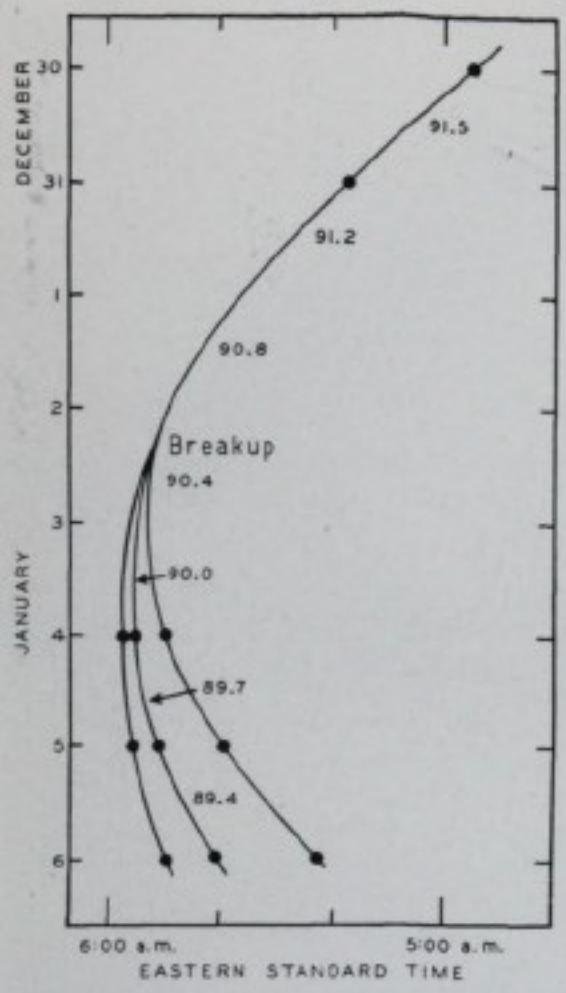
At Manhattan, Kansas, the MOONWATCH team led by W. S. Houston monitored the satellite with a short-wave receiver for three passages on February 2nd. The third time, at 7:44 p.m. Central standard time, Explorer was seen crossing Orion's belt, of the 5th magnitude and visible for 10 degrees of its path.

Fall of Sputnik I Sphere Recorded by Radio

AS the first Russian satellite broadcast signals during the early weeks of its life, astronomers at the Ohio State University Radio Observatory tracked it with a simple interferometer antenna consisting of two horizontal dipoles half a wave length long, separated by a distance of 350 feet. They noticed that as the satellite approached Columbus its signal was always very rough and unsteady, but it became suddenly smooth and steady somewhat before the satellite reached its nearest point to the antenna.



This is a typical satellite burst recorded by the Ohio State WWV receiving apparatus. The small spikelike bursts were probably caused by transmission from meteor trails.



In this example of Dr. Kraus' method, the dots show observed 40th-parallel crossings at the dates and times indicated. Curves connecting these points demonstrate how the disintegration of 1957α2 was inferred. The periods of revolution are labeled in minutes.

This effect was believed caused by the bouncing of gas molecules into the space ahead of the satellite, for they have very long mean free paths in the rarified atmosphere hundreds of miles high. Since many of the molecules may be already ionized, there could result an increased ionization density in front of the satellite without requiring ionization of the molecules by the satellite.

The belief in such ionization along a satellite's path led John D. Kraus, radio astronomer at Ohio State, to experiment with a phenomenon like that already used for long-distance radio communication via meteor trails (*Sky and Telescope*, October, 1956, page 541). At Wittenberg College, Springfield, Ohio, L. R. Wylie and H. T. Castillo had recorded signals from WWV during the night, even when the ionospheric ionization density was so small as to produce negligible signals from the WWV transmitter at Arlington, Virginia. When a meteor streaked through the ionosphere, however, it produced a sufficient trail of ions to reflect the WWV signal to the Ohio receiver for a few seconds.

When Dr. Kraus tried this method on the satellites it met with immediate success, bursts of one to two minutes duration corresponding closely to times of passage of Sputniks I and II. Bursts on successive days followed a definite pattern, matching the satellite periods. For example, a burst might be noted at 4:00 one day, at 4:10 the next, 4:20 the next, and so forth. Such an object was taking 1,440 minutes (the number in one solar day) plus 10 minutes, or 1,450 to make an integral number of revolutions around the earth.

The antenna had a maximum response in directions east and west of Columbus, so the bursts in the WWV reception corresponded closely to 40th-parallel crossings of the satellite object, and on some days two successive passes of the same object were recorded. While Dr. Kraus was using this system, bursts following a systematic day-to-day trend were noted for the satellite sphere (1957α2), for 1957β, and for a couple of objects presumed to be the nose cones of each.

But on January 4th, several bursts appeared when only one had been expected for the passage of the Sputnik I sphere. On succeeding days the bursts became more separated in time, just as if the satellite had broken into pieces, each having different aerodynamic drag or initial orbital velocity. On January 6th, the first and last were separated by about 27 minutes – they were traveling some 8,000 miles apart.

By connecting the observed points with curves as shown in the diagram and extrapolating backward, Dr. Kraus estimated the single object orbiting in December broke into pieces about January 2nd or 3rd, just after the date predicted for the disappearance by the Smithsonian Astrophysical Observatory.

By January 6th, no less than eight distinct sizable pieces could be tracked by means of their day-to-day periodicity. The next day one had disappeared, by January 8th three more, and by the 9th all but one were gone, either fallen or disintegrated into such small fragments as to be undetectable. The last object disappeared completely on January 10th, which was 98 days from the launching date of Sputnik I. The end of the 23-inch sphere seems to have been a gradual rather than an abrupt affair. Prof. E. E. Dreese, chairman of the department of electrical engineering at Ohio State, suggests that the complex fabricated structure of the satellite may have burned apart at its weakest points on re-entry into the denser layers of the earth's atmosphere.

Three communications describing these satellite observations in complete detail have been prepared by Dr. Kraus and his associates for the March issue of the *Proceedings* of the Institute of Radio Engineers.

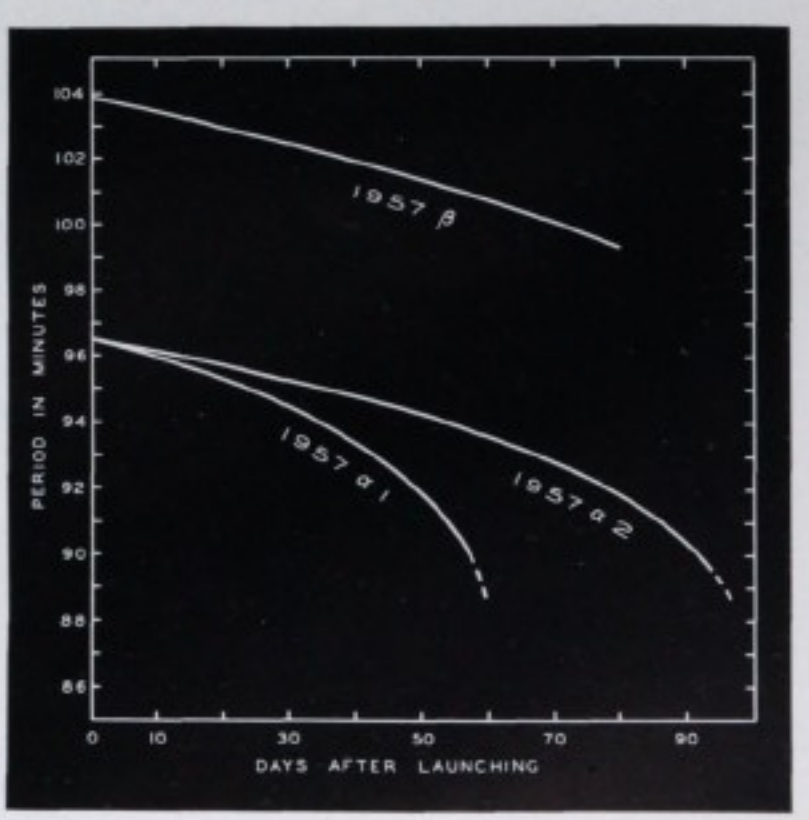
Changes in Sputnik Orbits

EVEN THOUGH an artificial satellite may revolve around the earth at a height so great that all but a small trace of the atmosphere lies beneath it, this trace will eventually change the satellite's orbit dramatically. The effects of such air resistance were foreseen in some detail by astronomers long before the first Sputnik was launched.

The initial effect of atmospheric drag is to reduce the satellite's orbital velocity, and this loss of speed allows the satellite to fall downward into a smaller orbit. The period of revolution in this orbit is, however, shorter than the original period, in obedience to the laws of mechanics, and the net effect is that of a gain in the satellite's speed of revolution.

But the density of the atmosphere increases rapidly with diminishing height; hence, the moonlet will descend and its period shorten at an ever-accelerating tempo. By the time the satellite requires only about 87½ minutes to circle the earth, air drag is so great that very little lifetime remains until the satellite falls to earth or burns up like a meteor in the dense lower atmosphere. For comparison, if a moonlet could revolve just above the earth's surface, its theoretical period of

(TO PAGE 233)



The cumulative effect of air drag causes a progressive shortening of a satellite's period. These curves are based upon Smithsonian Astrophysical Observatory orbit determinations. The upper curve, for Sputnik II, shows that it will take much longer to fall to the critical period, about 87½ minutes, than did the components of Sputnik I, in the lower curves.

Note the contrasting appearance of NGC 253 in blue and red light in these pictures from the Cape Observatory atlas. The one-hour exposure on the left was obtained November 10, 1953, on an Eastman 103a-O blue-sensitive plate with no filter. At the right is a 2½-hour exposure, taken the previous night, on Eastman 103a-E red-sensitive emulsion with an Ilford 205 filter. There is a much greater concentration of light in the inner spiral arms of the galaxy in the red picture. In blue, the nucleus is small, with a zigzag appearance; in red, this is replaced by a bright featureless patch.

Among Southern Galaxies — NGC 253

IN SCULPTOR, near the south galactic pole, lies the large late-type spiral nebula NGC 253. It has the 1950 coordinates: right ascension $0^h\ 45^m.1$, declination $-25°\ 34'$. It bears no Messier number, that astronomer having overlooked it in compiling his famous list of bright nebulae and clusters; the earliest recorded observation of NGC 253 was by William Herschel.

The three different pictures on these pages are from the Cape Photographic Atlas of Southern Galaxies. They show how its appearance differs depending on the color of the light which the filter-plate combination records.

NGC 253 is classified as SAB (s)c in G. de Vaucouleurs' new system, as is M83 pictured last month. Both objects are intermediate in form between normal and barred spirals, with fairly loose arms. According to him, the total apparent brightness of NGC 253 matches a star of photographic magnitude 7.5.

It is tilted nearly edgewise to our line of sight, the brighter portions covering a sky area 22 by 4.5 minutes of arc, but Dr. de Vaucouleurs traces fainter extensions out to 28 by 5.2 minutes.

In the facing picture, the spiral arms show a granular structure, indicative of partial resolution into stars of the 18th magnitude and fainter. There are also some rather brighter blobs of emission nebulosity, best seen in red light.

The rotation of NGC 253 has been studied by D. S. Evans, who finds the maximum rotational velocity, about 600 kilometers per second, at points some 5.5 minutes or arc out from the center of the system. The upper side of the central bulge must be nearer to us than the other, because so many dark patches of obscuring matter are seen there. Consequently, in this spiral the arms are trailing as the system rotates.

The galaxy as a whole is coming toward us at 70 kilometers per second — the largest velocity of approach of any galaxy outside our local group.

NGC 253 is one of a number of bright galaxies near the south galactic pole, others being NGC 24, 45, 55, 247, 300, and 7793. Dr. de Vaucouleurs has described them as belonging to "the most remarkable grouping of such nearby objects" (*Sky and Telescope*, October, 1957, page 587).

FACING PICTURE: The spiral galaxy NGC 253, as it appears in blue-green light. This is an enlargement of a 90-minute exposure with the 74-inch reflecting telescope of Radcliffe Observatory, Pretoria, South Africa. It was taken November 9-10, 1953, on Eastman 103a-E emulsion, with an Ilford 623 blue-green filter. The reproduction scale of this picture is 5.5 seconds of arc per millimeter.

These are some more photographs in a monthly series of southern-galaxy pictures from the new atlas compiled by the Royal Cape Observatory, as described on page 519 of the September, 1957, issue of "Sky and Telescope." The series began in the February, 1958, issue. Several hundred exposures were made by Cape staff members with the 74-inch reflector, in order to obtain the two dozen high-quality negatives selected for the first installment of the atlas. The pictures are being published with the permission of Her Majesty's Astronomer at the Cape, R. H. Stoy. Each atlas print is accompanied by descriptive material written by David S. Evans, astronomer on the Cape Observatory staff.

Henri Poincare and his Cosmogonical Studies

OTTO STRUVE, *Leuschner Observatory, University of California*

FORTY-FIVE YEARS ago, the French mathematician Ernest Lebon wrote of Henri Poincare as the most brilliant of his nation's glories, and the embodiment of everything pure, unselfish, and good in France. An obituary article on Poincare by Jean Merlin in 1914 closes with the words: ". . . his was one of the most powerful minds that has ever appeared on the earth."

I remember that, when I was a student, my teachers unhesitatingly named him as the greatest astronomer of their generation, and as one of the greatest who had ever lived. Today, however, few astronomers realize how much we owe to this genius of French science, and even fewer have read any of his books and numerous memoirs.

Poincare was born in 1854 at Nancy, the son of a professor of medicine. A severe attack of diphtheria, at the age of five, resulted in a speech defect; this made him shy and somewhat awkward. Probably it was this mishap that caused him later to devote himself to science.

As a schoolboy he showed remarkable mathematical ability, which enabled him to grasp intuitively the fundamental ideas involved in the questions of his teachers. After graduation as a mining engineer from the Ecole Polytechnique in 1879, he was appointed instructor in mathematics at the University of Caen. Two years later, at the age of 27, he joined the faculty of the Sorbonne in Paris, where he taught mathematics, and theoretical and experimental physics. From 1896 to the end of his life he was professor of mathematical astronomy and celestial mechanics.

Poincare rapidly attained an outstanding position in French science. He declined the directorship of the Paris Observatory because he feared that the administrative duties would interfere with his creative work. In 1887 he became a member of the French Academy of Sciences, and in 1908 was elected to the Academie Francaise, where a year later he was joined by his famous cousin, Raymond Poincare, who later became president of France. In addition he served as chairman of the Bureau des Longitudes, as president of the government committee on observatories, and as a member of the council of the Paris and Meudon Observatories. He died unexpectedly on July 17, 1912, when he was only 58 years old and at the height of his abilities.

Poincare's principal astronomical researches were in celestial mechanics, summarized in his three-volume *New Methods in Celestial Mechanics* and his *Lectures on Celestial Mechanics*. In this field, he described his goal as the solution of the fundamental question of whether Newtonian gravitation can by itself explain all motions of astronomical bodies. The only means of answering the question, he wrote, was to compare the predicted consequences of the law of gravitation with the most accurate observations possible.

This picture of the Milky Way in Monoceros suggests the seeming resemblance of stars to molecules in a gas, a concept used by Henri Poincare in his approach to the problem of stellar motions.

Besides being a mathematical astronomer of profound originality, Poincare was a gifted author, and his *Science and Hypothesis* became a best seller. Among the most readable and enjoyable of his books was the last one, *Studies on Cosmogonic Theories* (1912), which was based upon his lectures at the Sorbonne in the winter of 1910-11 on the origin, development, and organization of the universe. Almost every one of its 14 chapters could have been printed practically unchanged as a *Sky and Telescope* article, if this magazine had existed then. Of course, in the 46 years since that time, all fields of astronomy have had enormous advances that would have astonished Poincare and changed many of his conclusions.

But even today, the depth of his understanding, the simple way in which he attacked intricate problems, and the remarkable clarity of his exposition are very attractive to readers. It is a pity that this book has never been translated into English. For those who read French, I recommend it as the best source of spiritual delight I know in astronomical literature.

To give the reader an appreciation of Poincare's reasoning, I shall not attempt a superficial outline of the many theories — from Kant and Laplace to Arrhenius and Belot — that he discusses in this book. Instead, I shall describe the content of a single chapter, chosen almost at random, entitled, "The Milky Way and the Theory of Gases."

In discussing this chapter, we shall not only glimpse something of Poincare himself, but shall be able to see how far astronomy has advanced in the past half century. Nothing in his chapter is foreign to present-day astronomers; all of it has been reworked over and over again, and modern treatises such as Chandrasekhar's go far beyond what Poincare could accomplish with the limited observational data at his disposal. I shall simplify the mathematical details. Lebon said, "Although this work contains some rather advanced mathematics, persons who only wish to learn something about the progress of science can read it because the conclusions of the theory are expressed in language understandable by everyone."

The idea Poincare uses of considering the Milky Way as a special kind of gas in which the particles are not molecules but stars goes back to Lord Kelvin. The laws governing molecular motions are well understood and, applied to this model, can

be expected to give some insight into the properties of the Milky Way galaxy.

Poincare assumes, to begin with, that this "gas of stars" occupies a spherical volume, through which the stars are distributed uniformly, but at such enormous distances from one another that collisions between them can be neglected. The motions of the stars in the sphere are to be regarded as controlled by Newton's law of universal gravitation.

Using a simpler mathematical formulation than Poincare employed, let us consider first a star at the boundary of the sphere, the latter's radius being called R. This star will experience a force of attraction, f, toward the center of the sphere. The numerical value of the force in dynes is equal to 7×10^{-8} (the gravitational constant) times the product of the entire mass, M, of the sphere, and the mass of the star, m, divided by the square of the distance R:

$$f = 7 \times 10^{-8} Mm/R^2.$$

This force, by Newton's second law of motion, is also equal to the product of the mass of the star, m, and a, its acceleration:

$$f = m\,a.$$

Combining the two expressions, we find for the star's acceleration:

$$a = 7 \times 10^{-8} M/R^2.$$

Let us assume that this same star is traveling in a circular orbit. To find its velocity, v, we can follow an argument precisely analogous to that on page 19 of *Sky and Telescope* for November, 1957. The result for a star at the outer boundary of the sphere is

$$v = (7 \times 10^{-8} M/R)^{1/2}.$$

Today, this is an important equation in many fields of astronomy. For example, we may apply it to the motion of an artificial satellite. In this case, M is the mass of the earth, 6×10^{27} grams, and R is the distance of the satellite from the center of the earth, say 7×10^8 centimeters. Substituting these numbers in the last equation, we find the velocity to be 7.7×10^5 centimeters per second, or very close to the 18,000 miles an hour of the actual Sputnik I.

Returning to the spherical gas of stars, since our own location is deep inside it we would have difficulty in measuring the circular velocity of any star at its boundary. Instead, we might be able to observe the motion of a star that dips far into the gas sphere, traveling through our own neighborhood. Its motion will not obey the three laws of Kepler, but will have special properties.

First of all, if a body moves inside a uniform spherical shell, it is subjected to no net attraction, because the attractions by different portions of the shell cancel out. Consequently, as the star descends into the gas sphere, it is attracted only by layers closer to the sphere's center and not by the material in the layers farther out than the star. If the distance of the star from the center is r, it is being attracted by an inner sphere whose mass is only $(r/R)^3$ times the mass of the entire sphere. Hence, the force acting on the star is not $7 \times 10^{-8} Mm/R^2$, but is only $7 \times 10^{-8} Mmr^3/R^5$ dynes.

At the boundary of the sphere, $r = R$, and the star's motion is of the simple, Keplerian type. At the center, r is zero, and the force is also zero.

A striking fact follows for a star moving in a circular orbit at any distance r from the center. Its orbital velocity is

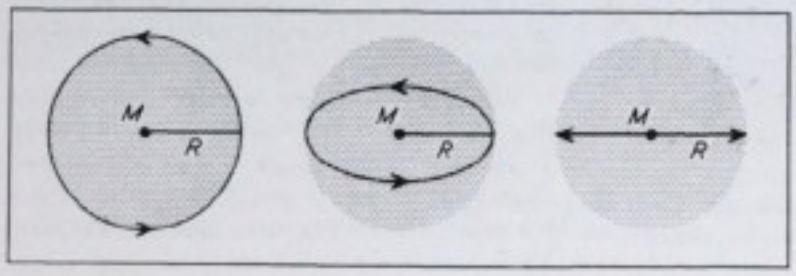
$$v = (7 \times 10^{-8} M/R)^{1/2}\, r/R,$$

which is smaller by the factor r/R than the circular velocity of a star at the outer boundary. This means that the periods of the two stars will be the same, that is, the homogeneous sphere will rotate as a solid body, without the shearing effects that would occur if the motion were Keplerian.

Thus, if we have three stars — one at the outer boundary and two within the sphere — moving in circular orbits around the center, they will always remain in the same relative positions. But a star outside the sphere would lag behind, because its period will obey Kepler's third law (period cubed is proportional to distance from the center squared).

This conclusion is actually illustrated by the rotations of galaxies: the inner parts rotate nearly as solid or rigid bodies, while the outer parts approximately obey Kepler's laws.

Henri Poincare, from a photograph taken shortly before his death in 1912. Besides his epoch-making contributions to pure mathematics, he made major advances in celestial mechanics, notably in the three-body problem, and in the question of the stability of rotating fluid masses. Much of the progress in celestial mechanics since Poincare's time has resulted from the exploration of avenues he opened up.



Three sketches to illustrate how stars may move with respect to the center of mass of the galaxy (M). Their motions have the characteristics of simple harmonic oscillators.

Another property of motion inside a homogeneous sphere deserves notice: The orbits are circles, ellipses, or straight lines with the center of the sphere at their centers, and not at their foci, as would be the case for planetary motions.

Of special importance for Poincare's discussion is the case of the harmonic linear oscillator, represented in the diagram. Such a star has zero velocity at the end points of its oscillation. Also, we may regard its motion as the projection, upon an orbital diameter, of the uniform circular motion of the first star in the same diagram. Therefore, the velocity of the oscillating star as it passes through the center of the sphere is equal to the circular orbital velocity of the other star, which we already know to be

$$v = (7 \times 10^{-8} M/R)^{1/2}.$$

Let us return to Poincare. He set himself the problem of calculating the radius of the Milky Way, on the assumption that it resembled a homogeneous sphere of stars. He next made the assumption (incorrect as we now know, but plausible in 1912) that the sun and its stellar neighbors are near the center of the Milky Way. Also, from the observed radial velocities

The central bulge of our neighbor, the Great Nebula in Andromeda, M31, is believed to resemble the nucleus of the Milky Way system. In this 60-minute exposure taken with the Jewett Schmidt telescope of Harvard Observatory, north is toward the lower left corner. Above and to the right of the nucleus is M32, one of M31's companion galaxies. The other is NGC 205, in the lower center.

and proper motions of stars he decided that the average space motion of a star is around 30 kilometers per second, or 3×10^6 centimeters per second. This is the quantity v in the previous equation.

Poincare did not know the total mass M of the sphere. But he could tell that the stars in the solar neighborhood are distributed at about one solar mass per cubic parsec. (This was because the 0.7-second parallax of our nearest stellar neighbor, Alpha Centauri, had been known since 1839.) Poincare assumed specifically that the average density of matter in the galaxy was that corresponding to one solar mass spread throughout a volume of radius of one million astronomical units — which would mean a density of about 1.4×10^{-25} gram per cubic centimeter.

The total mass of the homogeneous sphere of radius R is the product of its volume in cubic centimeters, $4\pi R^3/3$, and its density, ρ. Therefore, the velocity of a star traveling as a harmonic oscillator through the center of the sphere can be written,

$$v = [(7 \times 10^{-8}) 4\pi R^2 \rho / 3R]^{1/2}.$$

When we substitute numerical values and solve for R, the radius of the Milky Way system comes out about 1.5×10^{22} centimeters or 5,000 parsecs (16,000 light-years).

This result is too small by a factor of five or more, we know today. The error arose largely from Poincare's assumption, following Kapteyn, that our sun is close to the center of the Milky Way. Poincare did recognize that the Milky Way galaxy is not a sphere but is strongly flattened, and made further computations to allow for this fact, but we need not go into their details. The important thing is that Poincare could arrive at so nearly a correct order for the size of the Milky Way as early as 1910-11, when the distances of only a few nearby stars had been measured, out to about 50 parsecs, and nothing was known about the distances of star clusters or galaxies.

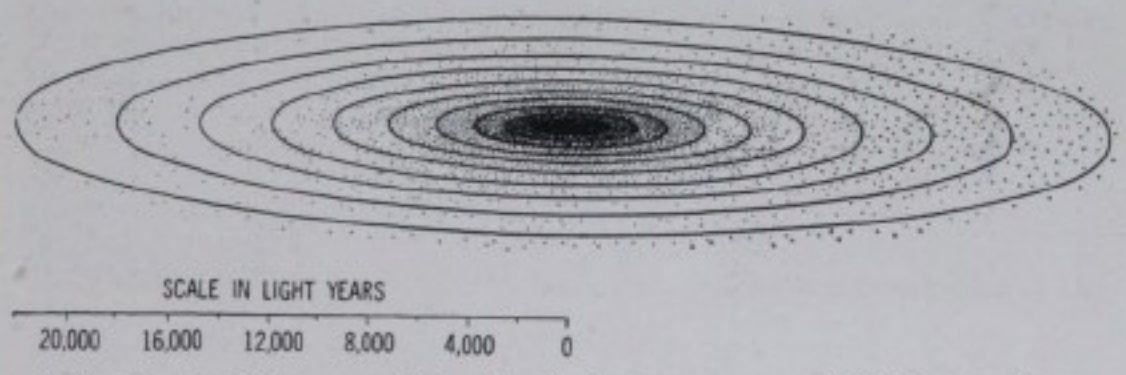
It is of some interest to apply Poincare's reasoning to the central bulge in a galaxy, such as our own or the great M31 Andromeda system. For the latter, we know from the work of H. W. Babcock, N. U. Mayall, and others, that the revolutions of stars around the center have approximately equal periods — the central parts of these galaxies rotate like solid bodies. Also, we know that the central bulges are approximately spherical in shape. For the Andromeda galaxy, this central region has been thought to have a radius of about 1,000 parsecs, or 3×10^{21} centimeters. This is the value R.

The absorption lines in the spectrum of the bulge of M31 appear greatly broadened by the Doppler effect, because one side of the rotating bulge is approaching us and the other side receding. A velocity estimate of 100 kilometers per second, or 10^7 centimeters per second, is probably not far from the truth. (Similar velocities have been derived by Leiden radio astronomers for the motions of the cold hydrogen gas in the hub of the Milky Way.)

If we write the velocity of a star undergoing harmonic oscillations through the center of the bulge as $v = (7 \times 10^{-8} M/R)^{1/2}$, we can compute M, since v and R are known. Substituting the numerical values mentioned above, we find for the mass of the bulge 4×10^{41} grams, or about 2×10^9 solar masses. Thus, the central bulge of the Andromeda system may contain roughly one per cent of the material in that galaxy.

The volume of the bulge is about 4×10^9 cubic parsecs. Hence there are about $(2 \times 10^9)/(4 \times 10^9)$ or 0.5 star per cubic parsec inside the homogeneous sphere. This final result is not unreasonable, for other astronomers have usually assumed an average of 0.5 star per cubic parsec at the center of our own galaxy. The agreement is considerably better than the roughness of the observational data would lead us to expect.

This application of Poincare's ideas about homogeneous gas spheres to the central part of the Andromeda galaxy is only one of many possible uses in modern astronomical problems. For example, a number of investigators have used the same concept in studying star clusters. But from this simple, lone illustration of Henri Poincare's pioneer work, we can gain some idea of his deep and stimulating insight into the fundamental problems of astronomy.



A decade after Poincare published his book on cosmogony, J. C. Kapteyn drew this cross-section of stellar distribution in the Milky Way system, with the sun considered near its center. The galactic equator is at right angles to the plane of the paper.

STAMFORD PLANETARIUM

The newly completed Edgerton Planetarium at the Stamford Museum and Nature Center, Stamford, Connecticut, was formally dedicated on January 19th. At present, there will be a public showing each Saturday at 11:00 a.m. Other demonstrations will be arranged during the week for school children.

The planetarium is named in honor of Mr. and Mrs. Malcolm J. Edgerton, who were active in museum affairs until their death in a plane crash in 1956.

Among those taking part in the dedication ceremonies were E. A. Matthiessen, museum president; Ernest T. Ludhe, its director; and Armand Spitz, designer of the planetarium projector. The first demonstrations were given by Raymond J. Stein, director of the Newark Museum Planetarium in New Jersey and a lecturer at the American Museum-Hayden Planetarium.

AMERICAN ASTRONOMERS REPORT

Here are highlights of some papers presented at the 99th meeting of the American Astronomical Society at Indianapolis, Indiana, in December, 1957. Complete abstracts will appear in the Astronomical Journal.

An Outburst of Comet Schwassmann-Wachmann 1

The periodic comet discovered on November 15, 1927, at Hamburg Observatory, Germany, by A. Schwassmann and A. Wachmann, is a most unusual object. Its almost circular orbit lies between those of Jupiter and Saturn, so the comet is observable during part of every year. And unlike most other comets, its distance from the sun and the earth does not undergo great changes as it revolves in its orbit.

Therefore, from geometrical considerations alone, the brightness of Comet Schwassmann-Wachmann 1 should not change by more than 1.3 magnitudes. Nevertheless, although this comet is normally as faint as magnitude 18 or 19, it may suddenly brighten by five or six magnitudes or more! From the comet's discovery until 1950, at least 32 temporary outbursts of this kind were recorded. Their cause is unknown, though a correlation with solar activity has been suggested.

At the Flagstaff, Arizona, station of the U. S. Naval Observatory, Elizabeth Roemer has used the 40-inch reflector to secure a photographic record of an outburst of Comet Schwassmann-Wachmann 1 during the late summer and fall of 1957. Her pictures, some of which are reproduced here, provide more detailed information than obtainable from earlier photographs with smaller instruments.

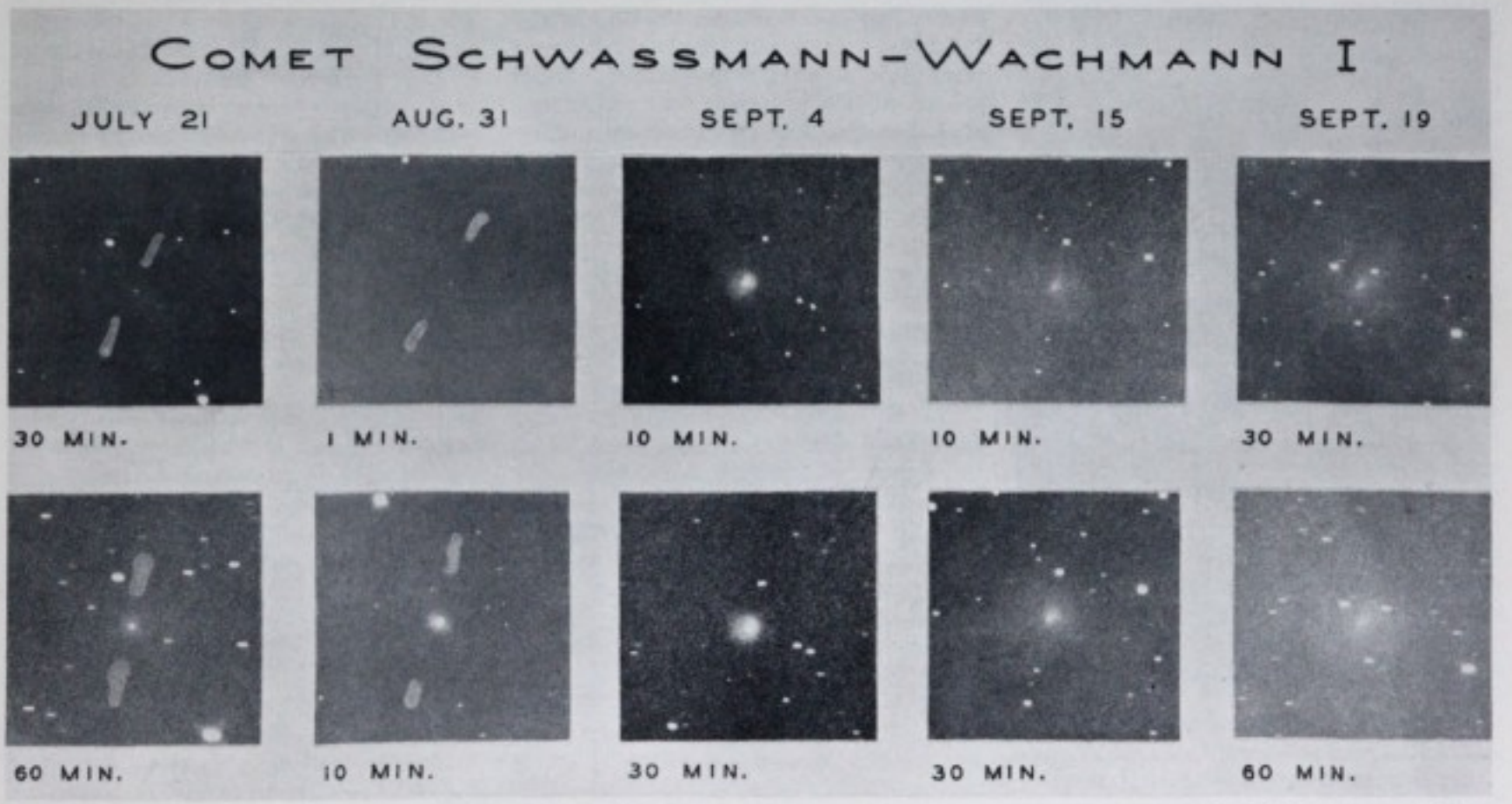
The first pictures show the comet in a quiescent state, on July 21, 1957, when it had a nearly starlike nucleus of magnitude 19.0, surrounded by a very faint nebulosity without definite boundaries. This dim glow is shown in the hour-long exposure.

When Dr. Roemer made her next observations, on August 31st, the comet had brightened to magnitude 13, its nucleus being of magnitude 15.0 and appearing absolutely stellar even when examined visually at 350x. The presence of a sharply bounded disk of nebulosity indicated, however, that the maximum-light stellar phase of the outburst had already passed, though probably by not more than one or two days. The 10-minute exposure of August 31st shows this incomplete disk of nebulosity, about 0.6 minute of arc in diameter and mainly on the north and west sides of the nucleus. By the next night, the nebulosity was visually more conspicuous than the nucleus, but photographs showed a much smaller and brighter coma than had been observed on the preceding night.

On September 4th, the comet was bright enough to be seen visually as soon as the telescope was pointed to it, even an hour before the setting of a 10-day-old moon. After moonset it was conspicuous, the visual diameter of its head or coma having doubled since September 1st. Photographically, on a 30-minute exposure, the nebulosity had expanded to a diameter of 0.8 minute, and was unsymmetrical with respect to the nucleus. The growth of the coma appeared to be taking place at about 0.14 kilometer per second, according to measurements of plates taken September 1st and 4th.

When the comet was next observed, on September 15th, a 10-minute exposure showed some nebulosity extending southeast from the nucleus. Were longer exposures not available, this nebulosity might easily have been mistaken for a fan-shaped tail, but a 30-minute exposure revealed it as merely the brightest portion of a diffuse disk fully two minutes in diameter. On September 19th, when the nucleus appeared stellar, of magnitude about 18.3, the surface brightness of the nebulous background was too low for the observer to be sure of its extent, although the impression of a short tail remained.

On November 11th, the comet was still attended by asymmetrical nebulosity, and



These are enlargements from direct photographs of Comet Schwassmann-Wachmann 1, secured by Elizabeth Roemer with the 40-inch reflector of the Flagstaff station, U. S. Naval Observatory. All these pictures are on the same scale, with north at the bottom and east to the right. Eastman 103a-O plates without filters were used for most but not all exposures. In the first four views, ink marks indicate the comet's location. Official U. S. Navy photographs.

The Holcomb Observatory and Planetarium of Butler University, as it appeared at the time of December's joint meeting of the American Astronomical Society and Section D of the American Association for the Advancement of Science. The dome contains a 38-inch reflector of the Cassegrain type.

the western portion of the coma appeared to have a crescent-shaped appendage with its convex side toward the nucleus.

Finally, Dr. Roemer observed Schwassmann-Wachmann 1 on December 11th, when it was bright once more, apparently having had another outburst a few days previously. Owing to the comet's proximity to the sun in the sky, further observations will not be possible until the spring of 1958 (probably in May).

No other comet is known to undergo repeated cataclysms of this description (although Holmes' comet showed a similar outburst in January, 1893). The desirability of spectroscopic and accurate photometric observations of Comet Schwassmann-Wachmann 1 is stressed by Dr. Roemer, particularly for the short-lived initial stages of outbursts.

A Study of the Stellar Association I Lacertae

At Harvard Observatory, William E. Howard, III, has searched for and found important related evolutionary characteristics in one of the expanding loose groups of stars known as stellar associations. This example is marked by some 30 early-type stars (spectral classes *O* and *B*) in the Lacerta region of the sky, at an assumed distance of 500 parsecs. These stars are moving away from each other as if they had a common origin in place and in time. The expansion age of I Lacertae is only about four million years — it is a very young star group compared with the age of the galaxy.

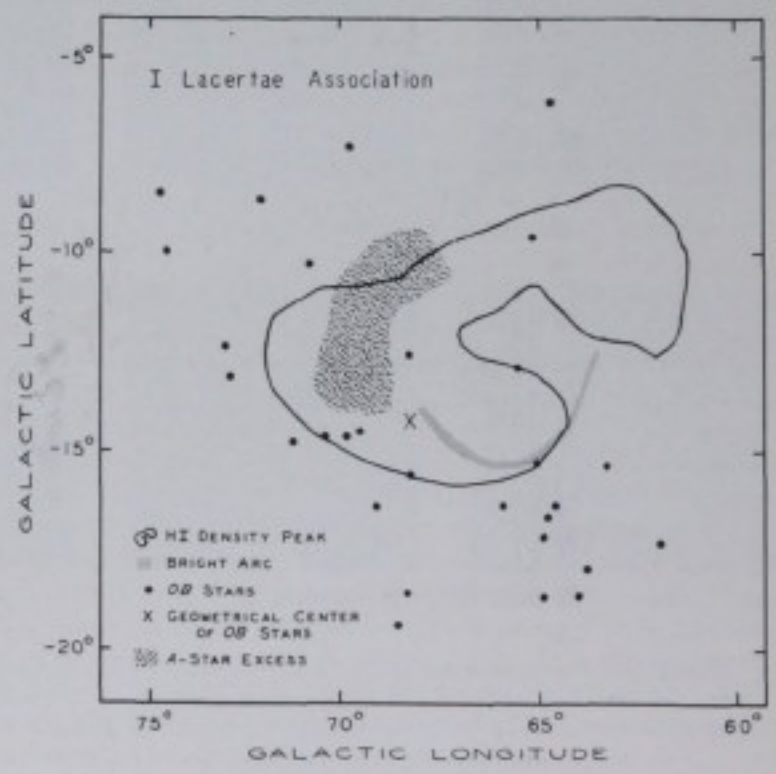
Are there any stars of later spectral types in the association? Their existence can be predicted on the basis of the cluster members already identified in spectral classes *O* and *B* (with absolute magnitudes between −3.75 and −1.25). Use of a method proposed by A. Sandage shows there should also be present about 81 stars with spectral types *A0* to *A5* (absolute magnitudes +1.25 to +2.75).

Mr. Howard has made a statistical study in the Harvard *Henry Draper Catalogue*, plotting the positions of all the *A* stars in this part of the sky. He finds there is a strong excess of such objects in the area shown on the chart, the excess being about five times the background number of *A* stars. This concentration lies within the Lacerta *OB* association, and the apparent magnitude of most of the *A* stars, about +9 or +10, is just right for the distance of the association. The observed number after elimination of the background stars is 90, which agrees well with the predicted number of 81. The combined mass of the stars in the association can be computed as about 1,700 times the sun's mass.

A-type stars, however, evolve more slowly than those of earlier types. When a star is first formed, it contracts and becomes hotter, moving from right to left in the spectrum-luminosity diagram. Four million years is approximately the time required for a star of absolute magnitude +1 (type *B9*) to have contracted to the main sequence. Therefore, in I Lacertae, stars of type *A0* and later should still be contracting toward the main sequence: they should show a larger scatter in position on the spectrum-luminosity diagram than stars of earlier types. This effect has been confirmed observationally by C. Seyfert and R. Hardie.

Radio observations, at the 21-cm. wave length of neutral hydrogen, indicate that about 6,000 solar masses of that gas are involved with I Lacertae. An elliptical ring of 21-cm. emission is centered at right ascension $22^h\ 29^m$, declination +43° 08′ (1957), about four degrees north of the nucleus of the *OB* association. The major and minor axes of the neutral hydrogen ring, at the assumed distance of 500 parsecs, are 65 and 35 parsecs, respectively.

Optically, there is a bright semicircular arc of luminous material having approximately the same center and dimensions as the neutral hydrogen; this is recorded on Plate 537 in the Palomar-Schmidt Sky Survey Atlas. The region of *A* stars tends to complete the arc in its northern section; furthermore, G. Herbig has found four variable stars of the T Tauri type in the bright arc. Such stars are among the youngest known, possibly being actually in the process of formation.



The major features of the I Lacertae association, according to William E. Howard, III. Neutral hydrogen gas is densest within the curved line. The arc of emission nebulosity, and the region where an excess of A stars is found, are indicated by shadings.

Magnetic Stellar Envelopes and Planetary Nebulae

At the University of Michigan Observatory, Lawrence H. Aller has considered the role magnetic fields may play in the evolution and structure of planetary nebulae. Photographs taken with the 200-inch

These three faint galaxies in Ursa Major are NGC 3991 (right), 3994 (upper left), and 3995. The second of these is an ordinary barred spiral, type SBc, but the others are small, very blue systems of the Haro type. Mount Wilson and Palomar Observatories photograph.

telescope show that many of these objects possess complex forms — simple, orderly configurations are relatively rare. R. Minkowski and others have noted that the structural appearance of a number of planetaries suggests the presence of magnetic fields.

Since the gas of a planetary nebula is fully ionized, the hydrodynamical streaming of the material would be strongly influenced by a magnetic field, and the latter's controlling effect might be fully as great as radiation pressure and, perhaps, gas pressure as well. Dissipation of the nebular material by simple expansion of the gas might also be inhibited. Electrons cannot stream freely at right angles to the lines of force, and electrostatic forces prevent a separation of ions and electrons, with the result that the nebular gas as a whole could move along the lines of force with ease, but perpendicular thereto only with difficulty.

The major problem is to estimate the size and intensity of the magnetic field. Dr. Aller suggests that a field of 1/50,000 gauss may be sufficient to enable certain planetaries to retain their characteristic shapes against the disruptive effects of ordinary gas expansion and radiation pressure. The expansion of the shell then would occur in a "controlled" way and the peculiar nebular shape would be preserved.

It seems unlikely that the magnetic field is created as the planetary is formed. Dr. Aller suggests that it already existed in the outer envelope of the parent star. Certain red giant stars with magnetic fields may evolve to form planetaries. Not all magnetic stars may produce them, nor is it necessarily true that all planetaries have magnetic fields. Evidently, the formation of a planetary is a delicate process which can occur only when certain restrictive conditions are met.

Abnormally Blue Galaxies

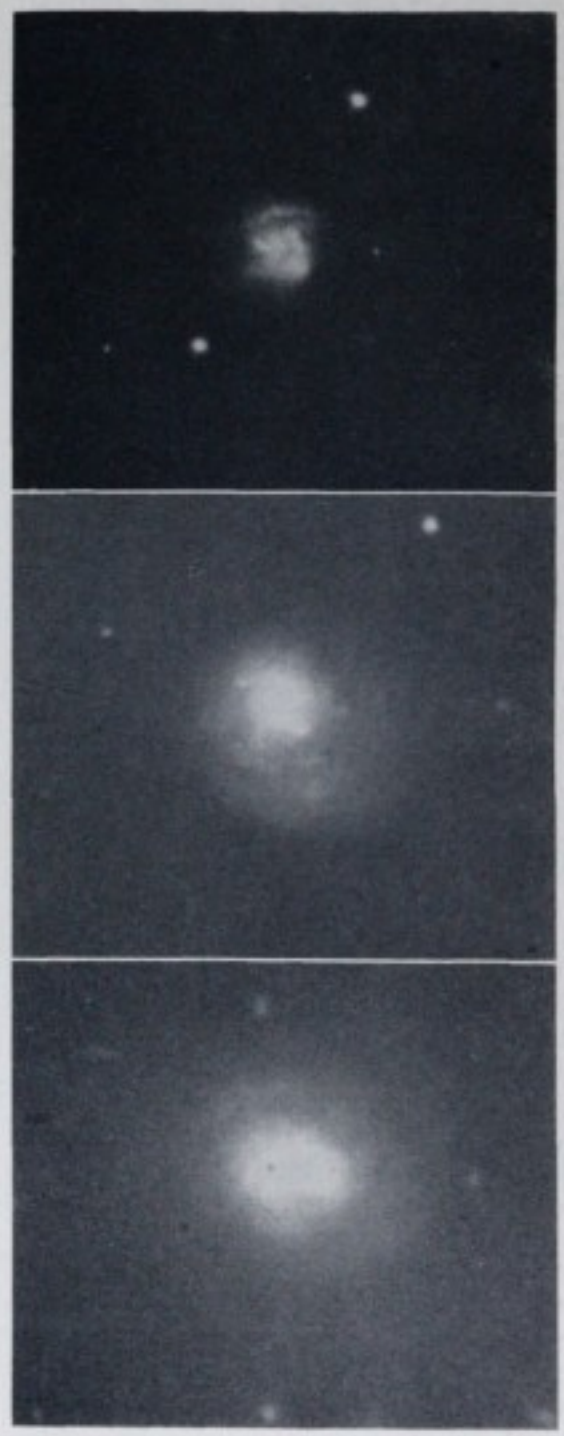
In March, 1956, at the Columbus meeting of the American Astronomical Society, G. Haro, of Tonanzintla Observatory, Mexico, reported his discovery of a number of extragalactic nebulae with abnormally strong light in the blue and violet regions of the spectrum (*Sky and Telescope*, June, 1956, page 359). To determine the nature of these objects, Guido Münch has been observing them spectroscopically and directly with the 100-inch and 200-inch reflectors of Mount Wilson and Palomar Observatories.

Dr. Münch has observed about half of the objects in the Haro list, finding them to differ rather widely in structure and luminosity. The most nearly normal galaxies among them are typified by the group NGC 3991-94-95, pictured above; it contains an open barred spiral, which is delineated by ionized hydrogen emission regions, as well as a double object resembling a Magellanic Cloud system, and a smaller spiral of high surface luminosity.

In contrast, Dr. Münch finds another class of Haro objects, more or less symmetrical in form, and with internal structure suggesting spiral arms. These arms, however, appear shorter and thicker than those in ordinary spirals. The nuclei are inconspicuous and ill defined, as seen in the picture of NGC 2415, photographed in yellow light, but their surface brightness is very high. The same comment applies to Haro 14 and 18, which in their central parts show a number of very bright and also large H-II regions.

These peculiar galaxies are small compared with typical systems. From the angular dimensions and the red shifts of Haro 1, 14, and 18, Dr. Münch finds their respective diameters to be 2,400, 1,000, and 2,300 parsecs. Such values should be compared with 14,500 parsecs obtained by the same method for the diameter of the SBc spiral in the group NGC 3991-94-95.

At Tonanzintla, Dr. Haro had found the spectra of these objects to be of very early type, and to have strong emission lines of ionized hydrogen and ionized oxygen (the forbidden doublet at 3726-29 angstroms is very strong). Dr. Münch suggests that no extraordinary phenomenon is needed to explain the strong violet color suspected by the Mexican astronomer; sufficient intensity would be



These three abnormal galaxies, from top to bottom, have numbers 1, 14, and 18 on Dr. Haro's list. The first and second are also known as NGC 2415 and 244, respectively. These samples of Dr. Munch's observations are reproduced from Mount Wilson and Palomar Observatories photographs.

given that region of the spectrum by the oxygen doublet and by the presence of very luminous blue *B*-type stars.

One such galaxy, NGC 1569, has been actually resolved into stars by W. Baade, who has observed in its central part between 10 and 20 blue stars with absolute magnitudes close to −10. From this case, we might infer that the excitation in this kind of galaxy comes from a few stars of great luminosity, type *O* or *B* supergiants, rather than from many fainter ones.

The Haro objects appear to be subluminous. For instance, those known to belong to the Coma cluster of galaxies are three magnitudes or more fainter than the brighter members of the cluster.

It seems probable that these peculiar galaxies are very young, in the sense that most of the stars responsible for their color and brightness have been recently formed. If old stars (like the sun) are present, they are of relatively little importance.

Rotation and Expansion of the Local Supergalaxy

Some years ago, G. de Vaucouleurs proposed that the majority of the brighter galaxies and a good many fainter ones belong to a flattened supercluster of galaxies (*Sky and Telescope*, May, 1953, page 181, and *Vistas in Astronomy*, Vol. 2, page 1584). The nucleus of this enormous system is marked roughly by the great Virgo cluster of galaxies, while the local group, including our Milky Way system, M31, M33, and other nearby objects, appears to be merely an outlying condensation. The over-all diameter of the system is about 100 million light-years on the adopted distance scale.

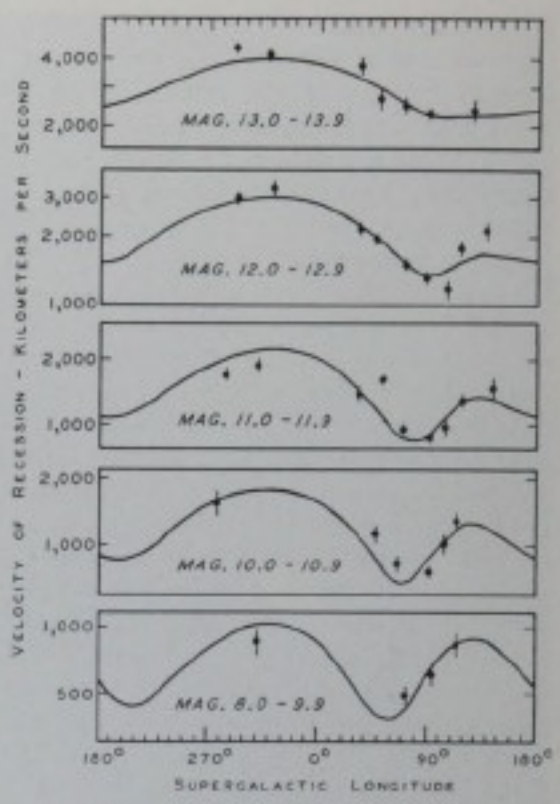
Now, from a statistical study of radial velocities in the new catalogue by M. Humason, N. Mayall, and A. Sandage (*Astronomical Journal, 61*, 97, 1956), Dr. de Vaucouleurs finds a differential velocity effect explainable by a general rotation of the local supergalaxy around a center in the Virgo cluster. The Lowell Observatory astronomer further believes the supergalaxy is differentially expanding.

Our position in the local supergalaxy is somewhat analogous to the one we occupy in the Milky Way system. Because of the sun's eccentric location far to one side of the galactic center, the Milky Way stars appear concentrated in the direction of the center, toward Sagittarius. In just this manner, our Milky Way galaxy and its neighbors are believed to be far from the center of the local supergalaxy, the distance to this center being estimated at some 30 to 35 million light-years. Such an eccentric position explains the well-known inequality between the numbers of bright galaxies in the north and south galactic polar caps. Only a few bright galaxies are seen in the anticenter direction, which falls in the southern galactic hemisphere of the sky. Furthermore, for galaxies fainter than the 10th magnitude, most members of the supergalaxy are seen in a belt 60 degrees wide crossing the northern galactic hemisphere.

Radio observations appear to confirm the concentration of galaxies and intergalactic matter in a belt around the sky. Several radio astronomers have found a band of enhanced radiation along the supergalactic equator that surpasses markedly the integrated intensity computed for the visible galaxies with normal ratios of their optical and radio energy emissions. As suggested by I. Shklovsky in 1954, most of the observed radio radiation may originate in a diffuse intergalactic medium which is also condensed in the local supergalaxy.

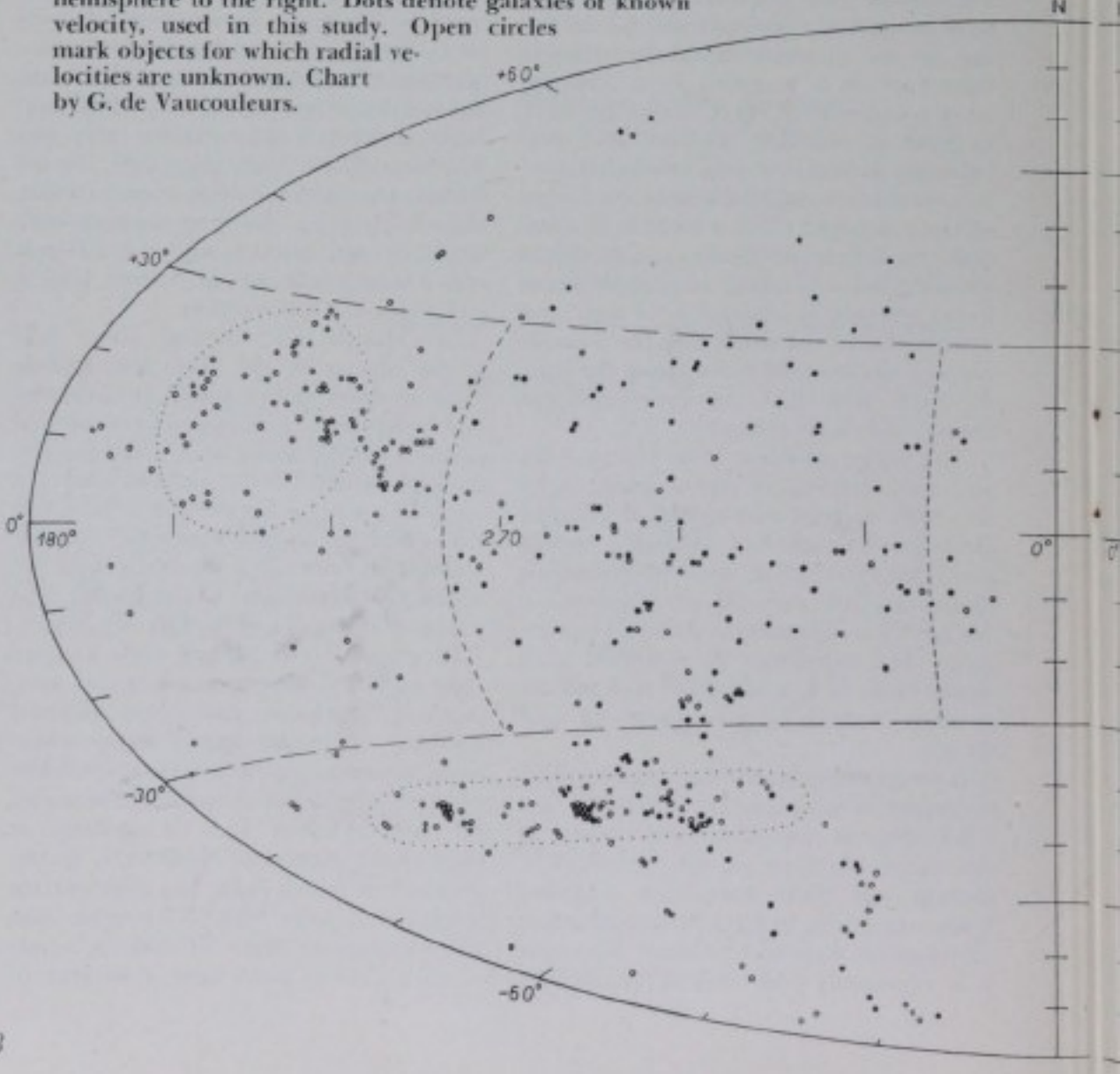
The equatorial plane of the local supersystem lies nearly at right angles to that of the Milky Way, its north pole being located at galactic longitude 15°, latitude +5°, in the constellation of Aquila. The supergalactic co-ordinates, *L* for longitude, *B* for latitude, have been computed by Dr. de Vaucouleurs for all the galaxies in the Shapley-Ames catalogue of bright galaxies (1932).

The strong flattening of the supersystem, of the order of five to one according to available galaxy counts in the north galactic cap, suggests that it may be rotating. In fact, if the concentration of bright galaxies toward a great circle of



Averaged radial velocities of galaxies in the supergalactic equatorial belt plotted against supergalactic longitude, in five magnitude intervals. For each plotted point, the vertical line indicates the probable error. The theoretical curve from Dr. de Vaucouleurs' hypotheses is drawn for each case. In the chart below, short-dashed lines delimit the regions of maximum and minimum velocities of recession.

The chart on these pages gives the observed distribution in supergalactic coordinates of galaxies having photographic magnitudes 8.0 to 12.9. The equator of the local supergalaxy is centered horizontally, with the northern galactic hemisphere to the right. Dots denote galaxies of known velocity, used in this study. Open circles mark objects for which radial velocities are unknown. Chart by G. de Vaucouleurs.



the celestial sphere is not a mere chance alignment of a number of independent clusters, that is, if the system forms a physical unit held together by gravitation, its flattening is a strong indication that it is rotating. This expectation seems to be borne out by the new red-shift data.

The accompanying graphs by Dr. de Vaucouleurs show how the mean values of the observed radial velocities depend on supergalactic longitude, for both bright and faint objects. The values of apparent recession (part of the general recession of galaxies in the expanding universe) have a broad maximum near $L = 320°$ (in the south galactic cap), and a deep minimum around $L = 80°$ (near the north galactic pole). This discrepancy between velocities in the north and south galactic caps had been noted by Sandage as a puzzling effect detracting from the usual assumption of an expansion proceeding uniformly in all directions.

But the characteristics of the curves, different for different magnitudes, and in particular the large discrepancy between velocities in the north and south galactic caps for galaxies of the same mean apparent magnitude, are not wholly explained by differential rotation of the supergalaxy. Dr. de Vaucouleurs has invoked the further concept that the system is also in a state of differential expansion: The rate of expansion is small or negligible in the dense central regions, but increases asymptotically outward in the regions where the space density of galaxies is less. It appears that gravitation counteracts expansion in regions where the space density of matter is sufficiently high.

An important consequence of the differential expansion of the local supergalaxy is that the *general* law of red-shifts cannot be calibrated by merely taking the ratio of the velocity and distance of the Virgo cluster; a correction must be applied to allow for the reduction of the expansion rate in the local supersystem.

The Lowell Observatory astronomer adopts the following provisional values:

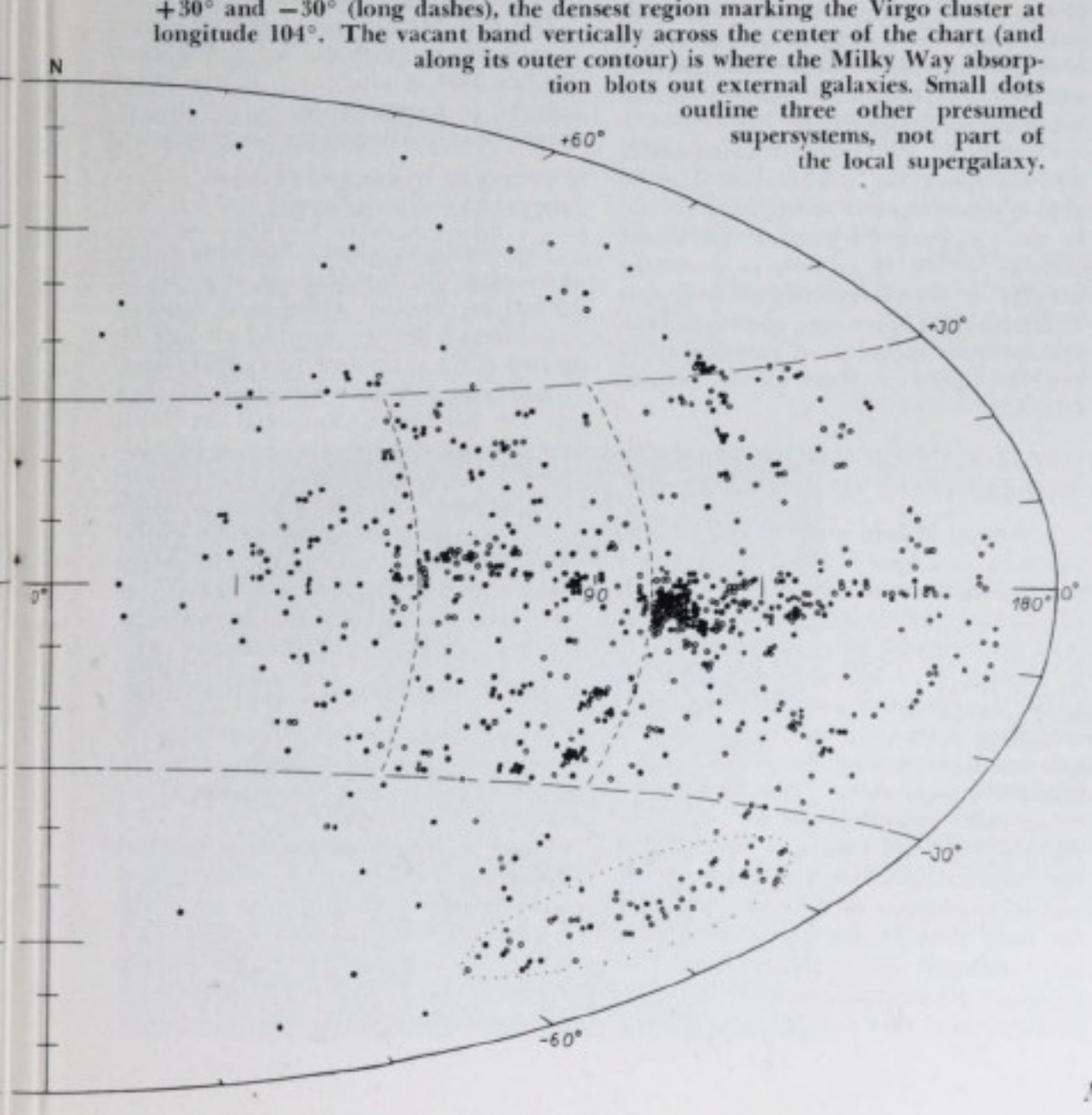
1. Assumed distance of Milky Way galaxy from Virgo cluster — 10 megaparsecs (32 million light-years).

2. Rotation period of local supergalaxy — on the order of 50 billion (5×10^{10}) years near the center, and from 100 to 200 billion years in the outer regions.

3. Rotational velocity of Milky Way galaxy around the supergalactic center — 500 kilometers per second toward galactic longitude 287°, latitude −14°; period of revolution some 100 billion years.

4. Total mass of the supergalaxy derived from its rotation — on the order of 10^{15} suns, a value consistent with the known mass of its nucleus (the Virgo cluster), about 10^{14} suns.

The principal belt of galaxy concentration lies between supergalactic latitudes +30° and −30° (long dashes), the densest region marking the Virgo cluster at longitude 104°. The vacant band vertically across the center of the chart (and along its outer contour) is where the Milky Way absorption blots out external galaxies. Small dots outline three other presumed supersystems, not part of the local supergalaxy.



MORE SATELLITE TALK

(Continued from page 223)

orbital revolution would be 84 minutes.

Many scientific teams in different parts of the world have been collecting and analyzing artificial satellite observations, optical, radio, and radar, and it may be a long time before all these results are combined into a final picture. At the present, however, much representative information is available, and Dr. John S. Rinehart, Smithsonian Astrophysical Observatory, suggests that readers can follow the orbit changes of present and future satellites. Numerical values of the periods and other orbital characteristics are often included in newspaper and magazine accounts, in the rocket and missile journals, and in such sources as the Harvard Observatory *Announcement Cards* and the British weekly *Nature*.

Dr. Rinehart proposed the diagram on page 223 to show the course of period changes for the satellites launched by the Russians in 1957. The uppermost curve is for Sputnik II, the middle curve for the spherical part of Sputnik I, and the lowest curve for the third stage of the October firing. The curves are plotted from Smithsonian computations, the orbit for 1957α1, for example, being based upon several hundred optical observations of that satellite.

To facilitate a comparison among the three bodies, their periods are plotted according to the number of days after launching, which was October 4, 1957, for Sputnik I (1957α), and November 3rd for Sputnik II (1957β).

There is a further consequence of the steep downward increase of atmospheric density. If the satellite's orbit is elliptical, then there is more drag at perigee (the lowest point of the orbit) than at apogee. But the effect of this is to decrease the apogee distance much more rapidly than the perigee distance, so the orbit becomes more and more nearly circular. Finally, a stage is reached in which there is appreciable drag on the object in all parts of its orbit, and from then on the fall is very rapid.

Thus, the spherical component of Sputnik I at apogee was about 1,000 kilometers above the earth's surface on October 9th, about 900 kilometers high on the 15th, and only 685 kilometers high on November 20th. In similar fashion, the apogee height of 1957β diminished from 1,700 kilometers on the day after launching to about 1,250 on January 21, 1958. For all three objects, the perigee distance began at about 200 kilometers above the ground, and remained nearly unchanged for weeks.

The reduction in orbital eccentricity that results from the decrease in the apogee distance while perigee hardly changes is illustrated by 1957β. It has had a steady drop in eccentricity, from 0.105 on November 4th, through 0.083 at Christmas, to 0.073 by January 21st.

NEWS NOTES

SALE OF HERSCHEL RELICS

The home of the famous English astronomer, Sir William Herschel, from 1786 to his death in 1822 was Observatory House, at Slough, in Buckinghamshire, England. Here he erected his great 40-foot reflector, and made most of his epoch-making discoveries. Observatory House was also the birthplace and home of his astronomer son, Sir John Herschel, and has remained in the family's possession.

It has recently been announced that the contents of this house will be sold at auction. The sale will include portions of the 40-foot and 20-foot telescopes, with their mirrors, made by Sir William himself; some of his eyepieces, and the lathe he used for their manufacture; and the instruments with which his sister, Caroline Herschel, observed. Also to be sold are the books and papers of Sir William Herschel, his letters, and his musical manuscripts.

Additional material includes the papers of Sir John Herschel on photography (as an active pioneer in this art, he discovered the use of hypo), and early fingerprint material by Sir William James Herschel (Sir John's son, who pioneered in the use of fingerprints in criminology).

The sale of most of these items will be conducted by the firm of Sotheby and Co., 34 New Bond St., London W.1, England, on March 3rd and 4th. Inquiries about the larger pieces, such as the telescopes, mirrors, and lathe, should be made to Joynson-Hicks, Lennox House, Norfolk St., Strand, London.

NEW RADIO ASTRONOMY TOOL

As radio telescopes are built in ever larger sizes, they are approaching such mammoth proportions that still larger instruments may soon become impractical, both because of high cost and difficulty of construction—a limit already reached by optical telescopes.

But the range of optical telescopes has in recent years been increased by improvements in photographic emulsions, photoelectric receivers, and other special devices. Now the space-penetrating power of radio telescopes may likewise be increased, perhaps tenfold, by the development of a novel amplifier. It is called a *maser* (microwave amplification by stimulated emission of radiation), the term being coined in 1954 at Columbia University by C. H. Townes, who first constructed amplifiers of this type, using gas as the operating medium.

At Harvard University's McKay Laboratory of Applied Science last December 7th, a new type of crystal maser was put into operation. Built by N. Bloembergen, J. O. Artman, and S. Shapiro, this "three-level solid-state" maser is the first designed to operate at the wave length of 21 centimeters emitted by interstellar neutral hydrogen gas. Radio telescopes receiving 21-cm. radiation have become powerful tools for probing the depths of the Milky Way, greatly increasing our knowledge of the structure of the galaxy.

A single crystal of potassium cobalticyanide forms the heart of the Harvard maser, containing a half-per-cent impurity of potassium chromicyanide. This crystal, about the size of the outermost joint of a man's thumb, is kept by liquid helium at a temperature of only two degrees above absolute zero.

The amplification is achieved by causing electrons of the impurity to shift from one energy level to another within the crystal, three discrete levels being used. An applied electromagnetic field pumps the electrons continuously from the lowest to the highest of these levels. Incoming 21-cm. radiation stimulates the electrons to drop from the top level to the middle one, and the excess energy is released as 21-cm. radiation far greater in amount than that originally received.

At the moment the device is much too large and too sensitive to its environment for use outside the laboratory. It must be made more compact and rugged before radio astronomy applications are possible. Eventually it will be used with the radio telescope of Harvard Observatory, being mounted at the focus of its 60-foot paraboloid. There the incoming radiation will be concentrated on the maser, causing it to produce more 21-cm. radiation that will be fed through wave guides to a conventional receiving system.

According to Harvard astronomer Thomas Gold, the combination may be able to detect neutral hydrogen as far out in space as optical telescopes now detect galaxies. It may be possible to determine whether or not there is neutral hydrogen in intergalactic space, and observations of the apparent recession of galaxies up to half the speed of light should become feasible.

CATALOGUE OF GALAXIES AND CLUSTERS OF GALAXIES

At Mount Wilson and Palomar Observatories, a catalogue is in preparation that may contain some 10,000 rich clusters of galaxies and 35,000 galaxies brighter than photographic magnitude about 15.5. E. Herzog, P. Wild, and F. Zwicky describe this extensive undertaking in a recent issue of the *Publications* of the Astronomical Society of the Pacific (October, 1957, page 409). They write:

"In order to extend the data given in the Shapley-Ames Catalogue of 1,250 of the brightest galaxies and in the NGC and IC catalogues, we have been engaged for some time in the compilation of a new catalogue listing the positions and apparent photographic magnitudes of all galaxies north of $\delta = -30°$ and brighter than $+15.5$. In addition, the catalogue will record basic data on all rich clusters of galaxies north of declination $-30°$ that can be recognized readily on exposures taken in yellow light with the 48-inch Schmidt telescope."

The new publication will have square charts six degrees on a side, centered approximately on plates of the National Geographic-Palomar Sky Survey, which also were taken with the 48-inch telescope. The charts already prepared indicate that, on the sky, many of the brighter galaxies are located near the centers of the larger clusters, thereby showing these clusters' proximity to us in space. The authors of the catalogue have found few distant clusters of galaxies in regions where there are concentrations among the brighter galaxies, which points strongly toward the existence of relatively local accumulations of intergalactic dust.

The first installment of the catalogue is expected to be ready for publication the first half of this year. If continued support is received, the entire project should be completed in the next five years.

NATIONAL OBSERVATORY DIRECTOR APPOINTED

The National Science Foundation has announced the appointment of Aden B. Meinel as director of the new National Astronomical Observatory, which will be erected in the southwestern United States. It will have a 36-inch reflector and later one of 80 inches, and will be built and operated by the Association of Universities for Research in Astronomy.

Dr. Meinel, who has been active in the project almost from its inception several years ago, has been associate director of Yerkes and McDonald Observatories since 1953. He is a leading authority on astronomical optics and the aurora.

AURORA PHOTOGRAPHS WANTED

On the night of February 10-11, a tremendous varicolored northern lights display was witnessed in many parts of the United States and Canada.

Photographic contributions of this brilliant event are invited. On Friday, February 28th, the selection of photos of this aurora will be made for the April issue of *Sky and Telescope*. Send your pictures by airmail special delivery to insure meeting this deadline.

IN THE CURRENT JOURNALS

TRACKING U. S. SATELLITES, by Jordan McQuay, *Radio-Electronics*, December, 1957. "With a receiving system that's sufficiently sensitive . . . anyone can pick up the coded signals from a U. S. satellite. And with slightly more elaborate equipment, you can help directly in locating and tracking the satellites as they pass over or near your area of the country."

Amateur Astronomers

CLARENCE L. FRIEND DIES

An internationally famous amateur astronomer for whom three comets were named, Clarence L. Friend, passed away at the age of 70, at Escondido, California, on January 18th. For his discoveries he had been awarded the Donohoe comet medal of the Astronomical Society of the Pacific. He was a fellow of the Royal Astronomical Society of London.

After searching for comets for more than six years, Mr. Friend was an independent discoverer of Comet Jurlof-Achmarof-Hassel on April 18, 1939. He then detected a new 10th-magnitude comet on November 1st of the same year. His third and fourth comet finds were made on January 16, 1941, and on November 22, 1945. The comet-hunting techniques he used were described by him in *Sky and Telescope* for May, 1953, page 194.

Mr. Friend used a 5-inch refractor for his work on comets. The principal instrument at his El Amigo Observatorio, located on a citrus ranch in the shadow of Palomar Mountain, was a 16-inch reflector; there many of his friends among the western amateurs came to observe.

THIS MONTH'S MEETINGS

Cleveland, Ohio: Cleveland Astronomical Society, 8 p.m., Warner and Swasey Observatory. Mar. 21, Dr. Karl G. Henize, Smithsonian Astrophysical Observatory, "The Tracking of the Artificial Satellite."

Dallas, Tex.: Texas Astronomical Society, 8 p.m., Dallas Health Museum Planetarium. Mar. 24, meteorological motion picture, The Unchained Goddess.

Geneva, Ill.: Fox Valley Astronomical Society, 8 p.m., Geneva City Hall. Mar. 18, V. A. Carpenter, "The Making of a Telescope."

Madison, Wisc.: Madison Astronomical Society, 8 p.m., Washburn Observatory. Mar. 12, Dr. Zdenek Kopal, University of Manchester, "Comets."

New York, N. Y.: Amateur Astronomers Association, 8 p.m., American Museum of Natural History. Mar. 5, Walter A. Stevens, American Telephone and Telegraph Co., "Graphic Prediction of Occultations."

St. Louis, Mo.: St. Louis Astronomical Society, 8 p.m., St. Louis Artists' Guild. Mar. 14, Dr. J. Allen Hynek, Smithsonian Astrophysical Observatory, "The New Age of Satellites."

Washington, D. C.: National Capital Astronomers, 8:15 p.m., Commerce Department auditorium. Mar. 1, John H. Nelson, RCA Communications, Inc., "Astronomical Technique of Forecasting Radio Weather."

INTERNATIONAL AMATEUR MEETING PROPOSED

A world-wide congress of amateur astronomers has been proposed, to take place in western Europe during February, 1961. The conclave, first of its kind ever attempted, would be held near the zone of totality of the solar eclipse of February 15, 1961. The eclipse will be total in parts of southern France and northern Italy.

In the latest issue of the *Strolling Astronomer*, publication of the Association of Lunar and Planetary Observers, such a meeting is suggested by Patrick Moore, of the British Astronomical Association. The Astronomical League, with a committee headed by Ohio amateur Steadman Thompson, is investigating this proposal, which has been made by several persons in addition to Mr. Moore.

MIDDLE EAST CONVENTION

The 1958 convention of the Middle East Region of the Astronomical League will be held in the physics building, West Virginia University, in Morgantown, West Virginia, April 19th. The Fairmont Amateur Astronomers Association will be the host society.

OFFBEAT MEETING

Bad weather – the bane of the astronomer – often causes amateur societies to replace a scheduled observing session by an impromptu meeting. The following excerpt from the January *Star Gazer* of the Bergen County Astronomical Society, Teaneck, New Jersey, tells what happened on one such occasion.

"Saturday, December 28th. As usual there was no observing at the December observing meeting due to the customary weather conditions. However the '13

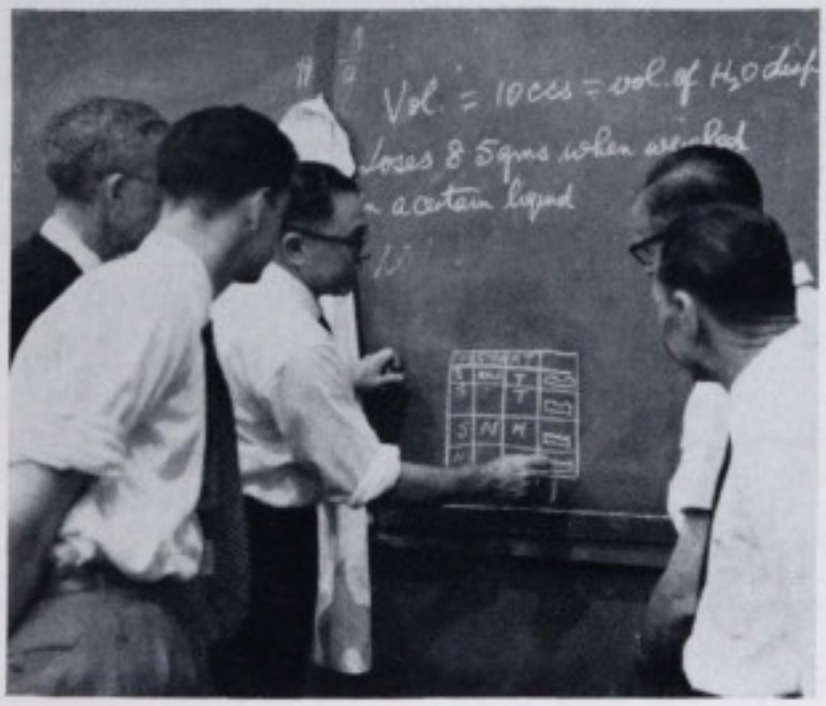
MIRROR MAKING IN SOUTH AFRICA

DURING a hobbies and crafts fair held recently at Durban, the Natal Centre of the Astronomical Society of Southern Africa showed telescopes and accessories made by its members. The keen public interest prompted the society to establish a telescope making class.

The Natal Technical College sponsored the project, providing a lecturer and a suitably equipped classroom with mirror making facilities. When the course was publicized, the response was beyond expectations – 40 students of all ages, including one housewife, enrolled. Two classes were set up, each meeting two hours weekly during a four-month period.

Each student made a 6-inch mirror of plate glass, testing and figuring it under the guidance of the undersigned and George Pollard, chairman of our society. Advice and instruction were also given on mounting the mirror and collimating the telescope. Various types of mountings were treated. One student made a very respectable equatorial-type mounting from plywood and broomsticks!

HEIN OTTENS
Astronomical Society of Southern Africa (Natal Centre)
57 Delew Court
110 Stanger St.
Durban, South Africa



Mirror making classes at Durban, Union of South Africa. Left: Assistant lecturer George Pollard shows the class how to keep a polishing record. Right: The youngest member of the class, Robert Archibald, and his mother work on their 6-inch mirror. Photos by Stuart Fulton.

members and four guests had a fine time eating Captain Lee's stew . . . and the Hiltbrunners' slumgullion. A symposium on bird-feeding stations was held by Mr. Ragsdale and Captain Lee, with several impertinent remarks offered from the floor. Jerry Logan suggested that the president be given a key to the observatory.

"The orrery was found to have been set up correctly for January, 1952 (except for Saturn, which had fallen on the floor and lost its rings). A large volume of water was spilled on the floor; the society extends its appreciation to Captain Lee for sweeping the floor. A few informal discussions on astronomical photography were held. The meeting collapsed at about nine o'clock."

In the same issue of the society's bulletin it is noted, "Webster gives the following as a definition for *stargazer*: 1. One who gazes at the stars; an astrologer; sometimes, jocosely, an astronomer. 2. Any of several spiny-finned marine fishes (family Uranoscopidae) whose eyes are on the top of the head."

NORTHEASTERN OHIO

A group is forming a local section of the American Astronautical Society in northeastern Ohio. Amateur astronomers in this area who are interested in joining should contact Robert Laws, 5180 W. 227th St., Parkview Village 26, Ohio, or Richard Pauley, 516 Moreley Ave., Akron 20, Ohio.

ANN ARBOR, MICHIGAN

From its opening in the spring of 1956 to the end of summer, 1957, a total of 8,118 persons attended 220 lectures at the Argus Planetarium, Ann Arbor, Michigan. An additional 2,500 were given brief demonstrations of the Spitz projector, according to the first annual report.

Although the planetarium is primarily for use by students at the Ann Arbor High School, during the year many invited groups came from as far as 100 miles.

EAST CLEVELAND, OHIO

A series of open nights for the public is being held at the Warner and Swasey Observatory, Taylor and Brunswick Rds., East Cleveland 12, Ohio. The lectures begin at 8 p.m.

The topic for March 27th and 28th is "Life and History of Our Sun"; for April 24th and 25th, "The Planets and Their Satellites"; and for May 22nd and 23rd, "Evolution of Stars."

For reservations, call the observatory, GLenville 1-5625, between 1 and 5 p.m.

Planetarium Notes

(Most planetariums give group and special showings by appointment.)

BALTIMORE: *Davis Planetarium.* Maryland Academy of Sciences, Enoch Pratt Library Building, 400 Cathedral St., Baltimore 1, Md., Mulberry 5-2370.

SCHEDULE: (Sept.-June), Monday, 3:45 p.m.; Thursday, 7:15, 7:45, 9 p.m.; Saturday, 2 and 3 p.m. Admission free. Spitz projector. Director, Paul S. Watson.

BLOOMFIELD HILLS, MICH.: *McMath Planetarium.* Cranbrook Institute of Science, Bloomfield Hills, Mich.

SCHEDULE: Saturday and Sunday, 2:30 and 3:30 p.m. Spitz projector. In charge, Robert T. Hatt.

BUFFALO: *Buffalo Museum of Science Planetarium.* Humboldt Parkway, Buffalo, N. Y., GR 4100.

SCHEDULE: Sunday, 2:30 to 5 p.m. (except summer). Admission free. Spitz projector. Director, Fred T. Hall.

CHAPEL HILL: *Morehead Planetarium.* University of North Carolina, Chapel Hill, N. C.

SCHEDULE: Sunday through Saturday, 8:30 p.m.; also at 11 a.m. and 3 p.m. Saturday, 3 and 4 p.m. Sunday. Zeiss projector. Manager, A. F. Jenzano.

CHARLESTON, W. VA.: *Hillis Townsend Planetarium.* Children's Museum, Public Library Building, Charleston, W. Va.

SCHEDULE: Saturday, 11 a.m. Admission free. Spitz projector. Director, Mrs. R. L. Sullivan.

CHICAGO: *Adler Planetarium.* 900 E. Achsah Bond Dr., Chicago 5, Ill., Wabash 2-1428.

SCHEDULE: Monday through Saturday, 11 a.m. and 3 p.m.; Tuesday and Friday, 8 p.m.; Sunday, 2 and 3:30 p.m. Zeiss projector. Director, Albert Shatzel.

DALLAS: *Dallas Planetarium.* Dallas Health Museum, Fair Park, Dallas 10, Tex., HA 8-5755.

SCHEDULE: Saturday, 10:30 a.m.; Sunday, 2:30 and 4 p.m. Spitz projector. Planetarium Educator, Mrs. Claudia Robinson.

DENVER: *Denver Museum of Natural History Planetarium.* City Park, Denver, Colo., East 2-1808.

SCHEDULE: Saturday and Sunday, 1 to 4:30 p.m. Spitz projector. Curator, W. R. Van Nattan.

FT. WORTH: *Charlie M. Noble Planetarium.* Ft. Worth Children's Museum, 1501 Montgomery, Ft. Worth, Tex., PE 2-1461.

SCHEDULE: Tuesday through Friday, 4 p.m.; Saturday, 11 a.m. and 2:30 p.m.; Sunday, 2:30 p.m. Spitz projector. Director, William Hassler.

INDIANAPOLIS: *Holcomb Planetarium.* Butler University, Indianapolis 7, Ind.

SCHEDULE: Saturday and Sunday, 4 and 8 p.m. Spitz projector. Director, Harry E. Crull.

KANSAS CITY: *Kansas City Museum Planetarium.* 3218 Gladstone Blvd., Kansas City 23, Mo., Humboldt 3-8000.

SCHEDULE: Saturday and Sunday, 3 p.m. Spitz projector. Director, Kenneth W. Prescott.

LANCASTER, PA.: *North Museum and Planetarium.* Franklin and Marshall College, Lancaster, Pa.

SCHEDULE: Tuesday and Thursday, 8 p.m.; Saturday and Sunday, 3 p.m. Admission free. Spitz projector. Curator, John W. Price.

LAQUEY, MO.: *Tarbell Planetarium.* Inca Cave Park, Laquey, Mo.

SCHEDULE: Sunday, 1 to 6 p.m., continuous. Spitz projector. Director, E. D. Tarbell.

LEXINGTON, VA.: *Sale Planetarium.* Virginia Military Institute, Lexington, Va.

SCHEDULE: Friday, 8 p.m. (except school vacations). Spitz projector. Lecturer in astronomy, A. Roland Jones.

LOS ANGELES: *Griffith Observatory and Planetarium.* Griffith Park, P. O. Box 27787, Los Feliz Station, Los Angeles 27, Calif., Normandy 4-1191.

SCHEDULE: Daily (except Monday and Tuesday), 8:30 p.m.; also 3 p.m. Saturday, and 3 and 4:15 p.m. Sunday. Zeiss projector. Director, Dinsmore Alter.

MINNEAPOLIS: *Science Museum.* Minneapolis Public Library, 1001 Hennepin Ave., Minneapolis 3, Minn.

SCHEDULE: Saturday, 10 a.m. and 2 p.m. Admission free. Spitz projector. Curator of education, Maxine B. Haarstick.

NASHVILLE: *Sudekum Planetarium.* Children's Museum, 724 2nd Ave. S., Nashville 10, Tenn., Chapel 2-1858.

SCHEDULE: Sunday, 2:45, 3:30, 4:15 p.m. Spitz projector. Lecturer, Sam Smith.

NEWARK: *Newark Museum Planetarium.* 49 Washington St., Newark 1, N. J., Mitchell 2-0011.

SCHEDULE: Saturday, Sunday (except first Sunday of month), and holidays, 2:30 and 3:30 p.m. Admission free. Spitz projector. Supervisor, Raymond J. Stein.

NEW YORK CITY: *American Museum-Hayden Planetarium.* 81st St. and Central Park West, New York 24, N. Y., Trafalgar 3-1300.

SCHEDULE: Monday, 2 and 3:30 p.m.; Tuesday through Friday, 2, 3:30 and 8:30 p.m.; Saturday, 11 a.m., 1, 2, 3, 4, 5 and 8:30 p.m.; Sunday and holidays, 1, 2, 3, 4, 5 and 8:30 p.m. Zeiss projector. Chairman, J. M. Chamberlain.

PHILADELPHIA: *Fels Planetarium.* Franklin Institute, 20th St. at Benjamin Franklin Parkway, Philadelphia 3, Pa., Locust 4-3600.

SCHEDULE: Tuesday through Sunday, 3 p.m.; Saturday, 11 a.m.; Saturday, Sunday, and holidays, 2 p.m.; Wednesday and Friday, 8 p.m. Zeiss projector. Director, I. M. Levitt.

PITTSBURGH: *Buhl Planetarium and Institute of Popular Science.* Federal and West Ohio Sts., Pittsburgh 12, Pa., Fairfax 1-4300.

SCHEDULE: Monday through Friday, 2:15 and 8:30 p.m.; Saturday, 11 a.m., 2:15 and 8:30 p.m.; Sunday, 2:15, 4:15 and 8:30 p.m. Zeiss projector. Director, Arthur L. Draper.

PROVIDENCE: *Roger Williams Planetarium.* Roger Williams Park Museum, Providence 5, R. I., Williams 1-5640.

SCHEDULE: Saturday, Sunday, and holidays, 3 and 4 p.m. (Oct.-June). Admission free. Spitz projector. Director, Maribelle Cormack.

SAN FRANCISCO: *Morrison Planetarium.* California Academy of Sciences, Golden Gate Park, San Francisco 18, Calif., Bayview 1-5100.

SCHEDULE: Daily (except Monday and Tuesday), 3:30 and 8:30 p.m.; also 2 p.m. Saturday, Sunday, and holidays. Academy projector. Curator, George W. Bunton.

SAN JOSE, CALIF.: *Rosicrucian Planetarium and Science Museum.* Park Ave. and Naglee Ave., San Jose, Calif.

SCHEDULE: Sunday and Wednesday, 2 and 3:30 p.m. Spitz projector. Director, Rodman R. Clayson.

SPRINGFIELD, MASS.: *Seymour Planetarium.* Museum of Natural History, Springfield 5, Mass.

SCHEDULE: Tuesday, Thursday, and Saturday, 3 p.m.; also 8:30 p.m. Tuesday; special star stories for children, Saturday, 2 p.m. Admission free. Korkosz projector. Director, F. Korkosz.

STAMFORD, CONN.: *Edgerton Planetarium.* Stamford Museum and Nature Center, Stamford, Conn., Davis 2-1646.

SCHEDULE: Saturday, 11 a.m. Spitz projector. Director, Ernest T. Luhde.

OBSERVER'S PAGE

Universal time is used unless otherwise noted.

Some Lunar Observing Problems

BOTH the enjoyments and rewards of the amateur observer are increased if he is using his telescope to answer some definite question. The moon's surface features offer many small puzzles that can be cleared up by careful and persistent amateurs, often with as small a telescope as a good 6- or 8-inch reflector.

Several good examples of these problems are found in the neighborhood of Mare Nectaris, in the southwestern portion of the lunar disk. The best times for observation of this region are when it is grazingly illuminated by the sun, about four or five days after new moon and three or four days after full moon. Favorable opportunities will occur on the evenings of March 8th, 9th, 24th, and 25th, as well as April 7th, 8th, 23rd, and 24th.

Back in 1927, a leading Austrian lunar investigator, Karl Müller, compiled a list of 174 problems which he published in a little book called *Studies of Lunar Photographs*. For each of 174 localities on the moon, he had found serious discrepancies between the Paris photographic atlas and the old visual maps and descriptions by Lohrmann, Beer and Mädler, Neison, and Schmidt.

Later, in 1941, a German student of the moon, H. I. Gramatzki, compiled charts that included all of these problematical regions. These were published privately in a pamphlet which, because of World War II, remained almost unknown to American amateurs. A few months ago, Leonard B. Abbey, Jr., of Decatur, Georgia, secured a copy, which he kindly made available in microfilm form to *Sky and Telescope*.

The accompanying map has been redrawn from Chart 5 of Dr. Gramatzki's publication. To his descriptions of some individual features have been added later information from *The Moon* (1955), by H. P. Wilkins and P. A. Moore. A few formations for which the problems now seem solved have been omitted from the following notes.

1. Southeast of Fracastorius and southwest of the smaller enclosure Fracastorius D is a peculiar feature for which the descriptions disagree badly. The Paris atlas shows three small rings fused together, Lohrmann a narrow valley, and Schmidt a figure-8-shaped ring plain. Its true character is not clear in the charts on pages 150 and 156 of the Wilkins-Moore book. Further drawings are desirable for this feature, which is labeled Fracastorius Y in the International Astronomical Union's atlas.

2. The small crater Rosse lies in the southwestern part of Mare Nectaris. There are contradictions among older maps in the number and arrangement of the small craterlets and spots in the vicinity of Rosse. Wilkins and Moore show four such objects in the area bounded by the dashed line, where Lohrmann shows three. A resurvey of the area under favorable lighting conditions should be useful.

3. Neison draws two rills or clefts, one running from Bohnenberger F to near Rosse, which is shown by Wilkins and Moore. They do not indicate the other rill, labeled Xi by Neison, running from the middle of the first rill southeastward toward Fracastorius. Does the latter rill exist? Adequate checking may require a skilled observer with a large telescope.

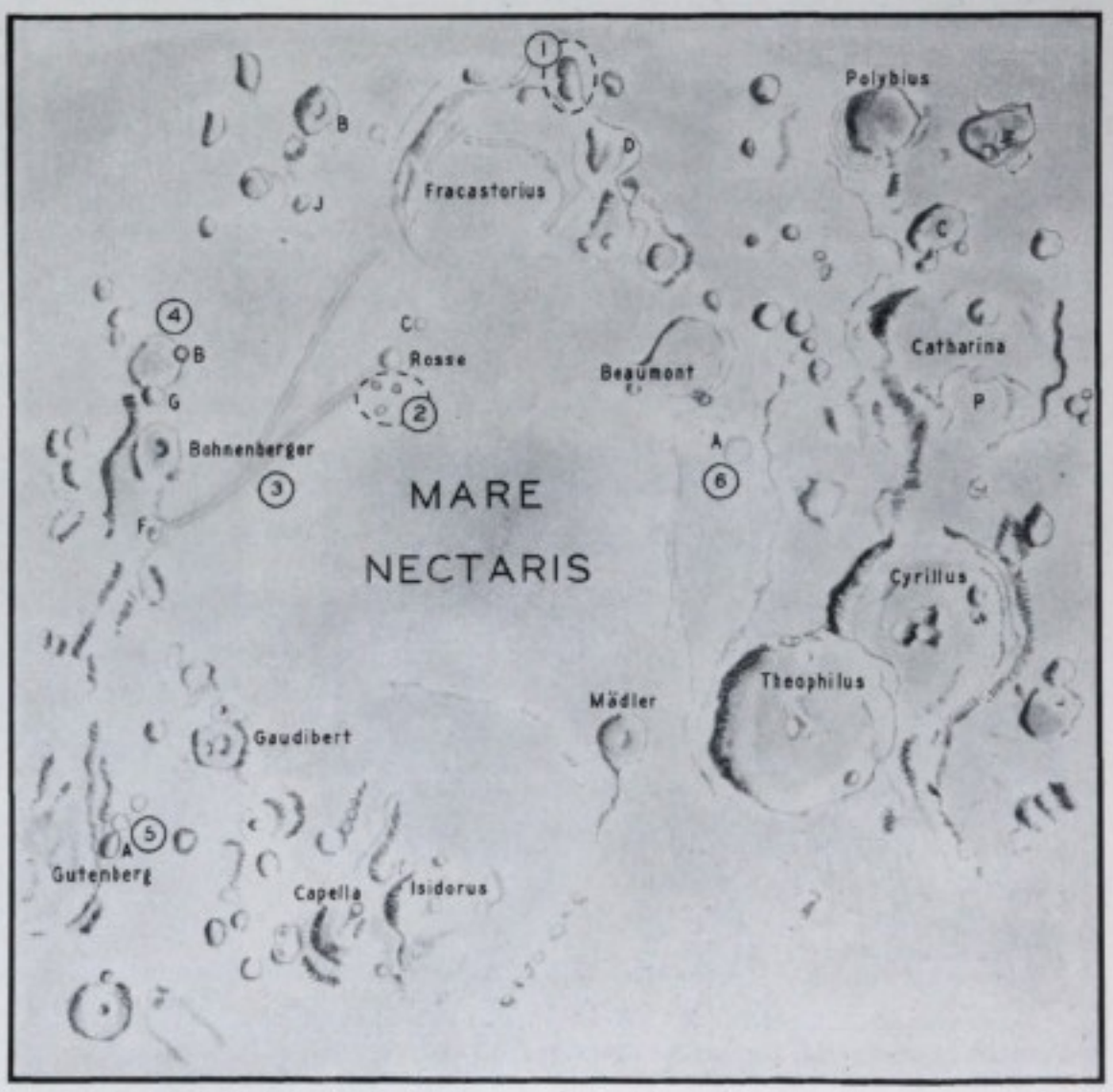
4. South of the crater Bohnenberger is another ring, Bohnenberger A, nearly as large, but inconspicuous because of its low walls. These are broken at the north end by the small, deep crater Bohnenberger G. However, Beer and Mädler (1837) and Neison (1876) describe a second small, but distinct, crater B, breaking the southeast wall of A. No such crater is shown by Wilkins and Moore.

This lunar neighborhood is excellently recorded on a photograph by J. H. Moore and J. F. Chappell with the 36-inch refractor of Lick Observatory, June 2, 1938. It was reproduced on page 160 of *Sky and Telescope* for February, 1956, and is Plate 3 of Lunar Crescent Sets. Although this picture reveals a break in the east wall of Bohnenberger A, there is no distinct indication of crater B. Does the latter exist? Is this possibly a case of lunar change?

5. Gramatzki asks whether the small object just southeast of the crater Gutenberg A is another crater or merely a shallow depression.

6. Gramatzki queries whether a central peak exists inside Beaumont A, and suggests that it may be visible only under rare conditions. Wilkins and Moore draw a central peak and four minute craterlets or spots inside Beaumont A.

J. A. and W. E. S.



Six problems for lunar observers are indicated by circled numbers, corresponding to the numbers in the text. This key map has been adapted from "Kritische Mondkarte," by the late H. I. Gramatzki. South is at the top.

SUNSPOT NUMBERS

The following American sunspot numbers for December were derived by Dr. Sarah J. Hill, of Whitin Observatory, Wellesley College, from AAVSO Solar Division observations.

December 1, 206; **2,** 206; **3,** 203; **4,** 264; **5,** 209; **6,** 251; **7,** 192; **8,** 167; **9,** 151; **10,** 121; **11,** 124; **12,** 116; **13,** 125; **14,** 151; **15,** 169; **16,** 205; **17,** 194; **18,** 213; **19,** 257; **20,** 288; **21,** 323; **22,** 342; **23,** 295; **24,** 312; **25,** 375; **26,** 307; **27,** 292; **28,** 292; **29,** 246; **30,** 238; **31,** 231. Mean for December, 227.9.

The following are mean relative sun-

spot numbers from Zurich Observatory and its stations in Locarno and Arosa.

January 1, 214; **2**, 213; **3**, 200; **4**, 217; **5**, 191; **6**, 192; **7**, 205; **8**, 210; **9**, 232; **10**, 252; **11**, 253; **12**, 255; **13**, 262; **14**, 270; **15**, 284; **16**, 290; **17**, 247; **18**, 230; **19**, 212; **20**, 190; **21**, 171; **22**, 173; **23**, 192; **24**, 137; **25**, 137; **26**, 143; **27**, 182; **28**, 160; **29**, 130; **30**, 110; **31**, 132. Mean for January, 202.8.

Zurich astronomer M. Waldmeier has supplied the following predictions for the smoothed monthly sunspot numbers: May, 154; June, 150; July, 146.

DEEP-SKY WONDERS

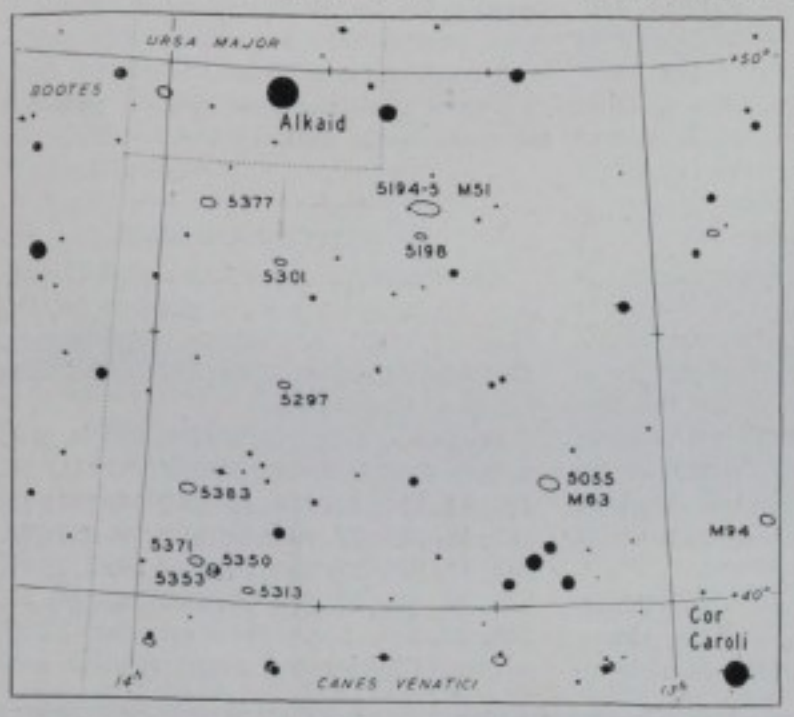
NORTHEASTERN Canes Venatici contains two bright Messier objects, the spiral galaxies M51 and M63, which we discussed here last May and June (Vol. XVI, pages 351 and 396). But this area under the end of the Big Dipper handle, from right ascension 13^h to 14^h, declination +40° to +50°, has many faint galaxies as well, to try the skill of the deep-sky observer.

For those needing new skies to conquer, 10 more objects are listed here that are of the 12th visual magnitude or brighter, are included in the Shapley-Ames catalogue, and are plotted in the Skalnate Pleso *Atlas of the Heavens*. The *New General Catalogue* lists 27 others; although they were discovered visually, they are difficult even in large amateur telescopes.

In Sir William Herschel's numbering system, I refers to bright nebulae, II to faint; Norton's *Star Atlas* gives the Herschel designations for NGC 5297, 5377, and 5383. In the last column, Hubble's types are S, Sa, Sb, and Sc, for spirals; SBc, barred spiral; E, elliptical; and Ir, irregular.

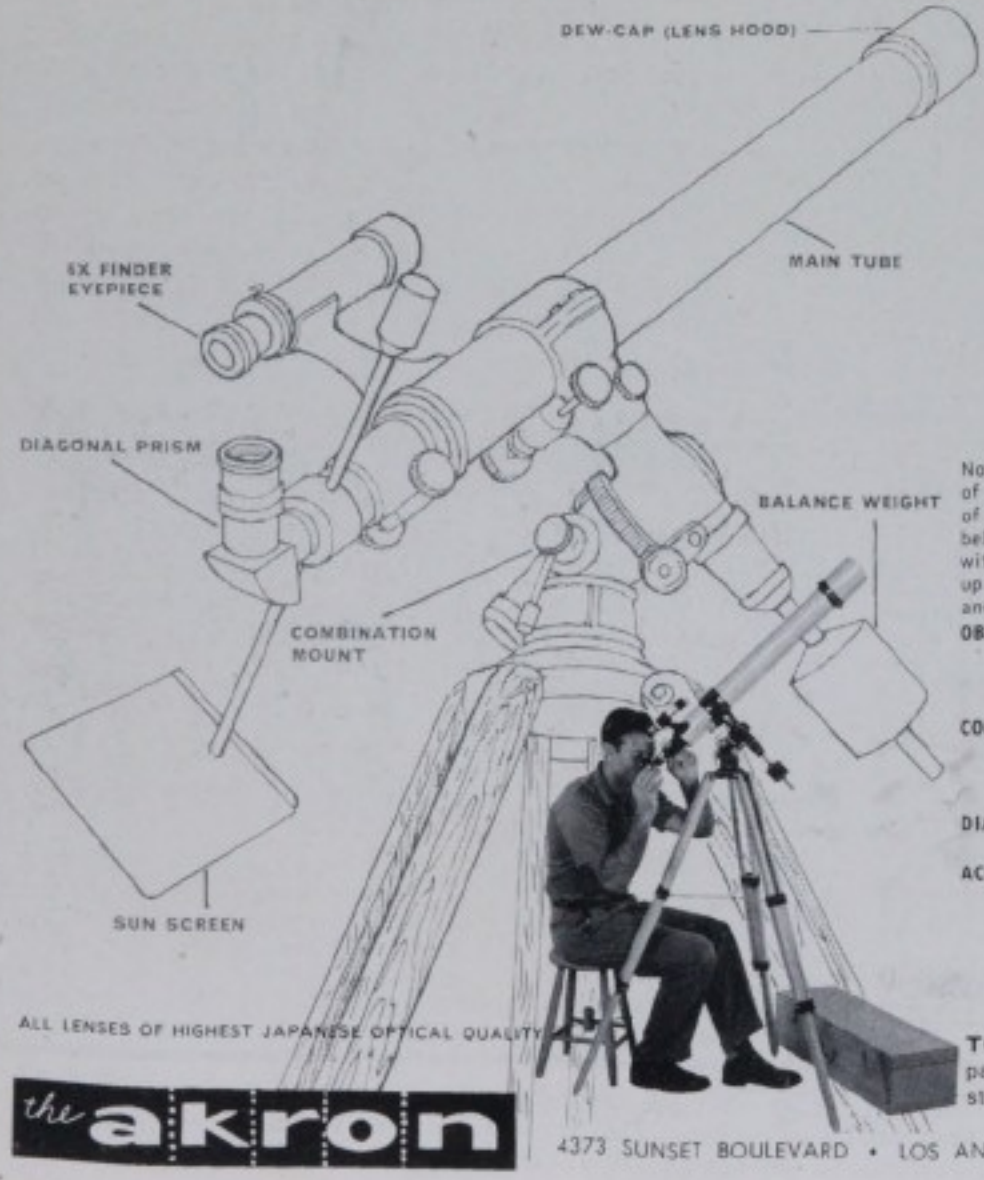
Since this is a difficult field, I would welcome any data on how many of these objects can be located by amateurs. As usual, a post card is the best means of communication.

WALTER SCOTT HOUSTON
Rte. 3, Manhattan, Kans.



The galaxies listed below are labeled in this key map, adapted from the Skalnate Pleso "Atlas of the Heavens."

NGC	*Herschel*	*R.A.(1950)* h	m	*Dec.* °	′	*Mag.*	*Size* ′	*Type*
5055	(M63)	13	13.5	+42	17	10	8.0 × 3.0	Sb
5194	(M51)	13	27.8	47	27	8	12.0 × 6.0	Sc
5195	I 186	13	27.9	47	31	8	2.0 × 1.5	Ir
5198	II 689	13	28.2	46	56	12	0.7 × 0.6	E
5297	I 180	13	44.3	44	05	12		
5301	II 688	13	45.0	46	24	12		
5313	II 711	13	47.7	40	13	12		
5350	II 713	13	51.2	40	37	12	1.9 × 1.0	S
5353	II 714	13	51.3	40	31	11	0.9 × 0.3	
5371	II 716	13	53.6	40	43	11	4.0 × 2.8	S
5377	I 187	13	54.3	47	27	11	3.0 × 0.6	Sa
5383	I 181	13	55.0	42	05	12	2.5 × 2.3	SBc



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SMITHSONIAN ASTROPHYSICAL OBSERVATORY

BULLETIN FOR Visual Observers of Satellites

NUMBER 8 — 60 GARDEN STREET, CAMBRIDGE 38, MASS. — MARCH, 1958

A Message to MOONWATCHERS

Each morning I find on my desk at headquarters a neatly tabulated resume of the MOONWATCH observations made during the previous 24 hours — usually the last few hours in cases of morning passages of a satellite. However, even before I reach the office, other copies of the data have been screened, processed, and delivered to the computers.

In quantity and quality, the majority of MOONWATCH reports have exceeded our expectations, attesting to the consistency and faithfulness with which amateur astronomers in the United States and elsewhere have discharged their self-imposed obligations, often under very trying conditions.

When a MOONWATCH observation is received by telephone, it is immediately transferred to a standard card form and checked for inconsistency, obvious errors of transmission, or the like. A copy of this card goes without delay to the computing room, where it is compared with the current ephemeris of the satellite. If several independent observations show the ephemeris sensibly in error, then selected MOONWATCH data are punched onto IBM cards in the "language" that the IBM 704 computer will understand. The computation is quickly completed by the machine, producing a revised set of orbital elements from which new, more precise predictions can be made. These are released to the press, MOONWATCH teams, and interested scientific groups, in the form of 40th-parallel crossing times, visibility areas, and so forth, for the Russian satellites.

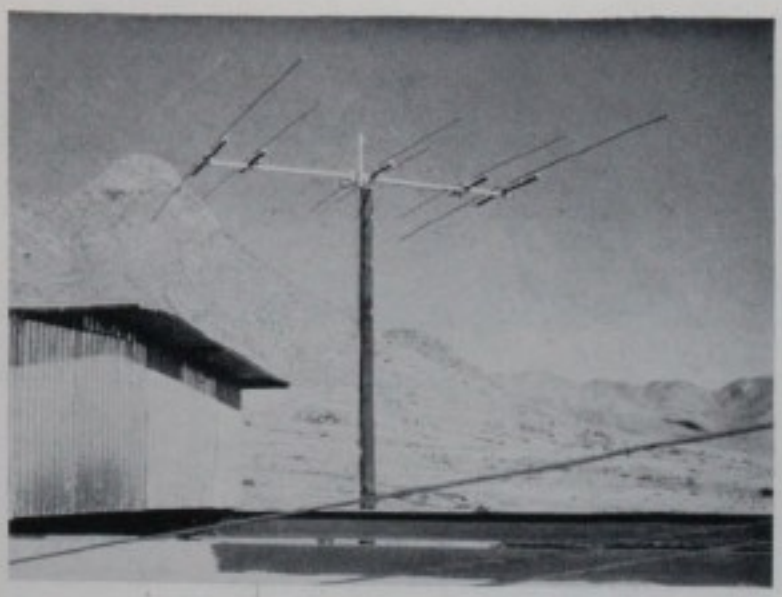
Orbit computing for a close artificial satellite is made complex by the effect of the earth's equatorial bulge, and to this must be added the effect of the resistance by the upper atmosphere to the satellite's motion. Not only is the density of the air at such great altitudes imperfectly known, but on each trip the satellite dips down into layers of increasing density, then rises out of them again. The problem is like trying to predict what would happen to the rate of a precise clock if some very fine sand were blown into the works.

If there were no air drag, it would be possible to compute an ephemeris of high precision several weeks in advance, despite the perturbations by the equatorial bulge of the earth. But the air drag requires constant re-evaluation, making visual and radio observations at frequent intervals very essential.

Another troublesome point is that the zones of twilight visibility move up and down across the world map, as a result of regression of the nodes of the orbit. For weeks at a time the first Russian satellites were visible at twilight over land areas only in high northern or southern latitudes. Therefore, very few observations came into Smithsonian headquarters during those times, and, consequently, the satellite timetable increased in error. When MOONWATCH observations again began to come in, however, the situation was quickly improved, in two or three steps of increasing accuracy. Thus, when a satellite first reappears over the mid-latitudes of the United States rather frequent corrections to 40th-parallel

Above: Members of the Terre Haute, Indiana, MOONWATCH team rehearse artificial-satellite observing during a practice session. During the last months of 1957, this team observed Russian satellites on four passages.

Left: One of the Japanese MOONWATCH teams conducts a simulated satellite-observing session. Note the type of telescope mounting, and the fact that the instruments are not set up along a single meridian line.

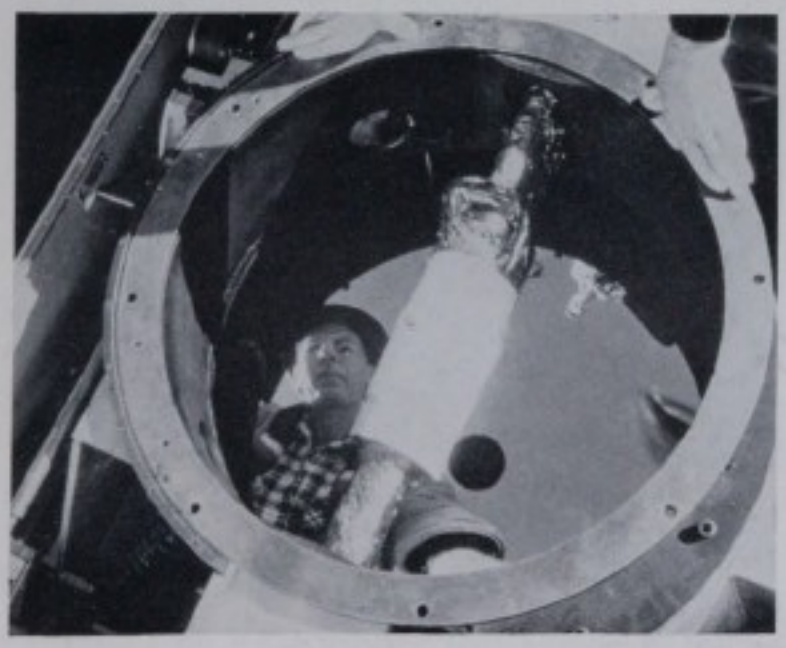


The scenes on this page show the installation of the first satellite-tracking camera. The station is located 22 miles by Highway 70 north of Las Cruces, New Mexico, in the Organ Mountains. At the left are seen the camera shed, an antenna for receiving WWV time signals, and St. Augustine Peak in the background. At the right, a derrick lifts the mirror-cell assembly into the shed. Note the system of counterweights around the outside of the cell.

crossing predictions from new data have to be issued.

Orbit computation is much simplified when a satellite's radio transmitter is operating, for then the radio clearinghouse of the Naval Research Laboratory in Washington, D. C., can keep a nearly continuous check on the object's position. Even then, MOONWATCH visual observations are needed, for it has been found that the optical and radio orbits may differ sensibly, because of the deviation in path of the radio signals from the satellite caused by the free electrons in the earth's upper atmosphere. In fact, it is by comparison of the radio and optical orbits that our knowledge of the electron density at high altitudes can be greatly improved.

The unexpected appearance of the Russian Sputniks and their high inclinations to the equator have made it necessary for MOONWATCH teams to act as interim tracking stations until our full complement of precision satellite-tracking cameras is in operation. We are now in the process of equipping and manning our dozen camera stations in widely separated parts of the world. Meanwhile, our amateur observers have accepted the interim tracking as a challenge, many without a formal request from the Smithsonian Astrophysical Observatory. Theirs has been a very valuable service superbly rendered. The data they have provided could come from no other source, especially after the radio batteries in the Russian satellites went dead.



Here the mirror cell is resting in place, but the plastic protective wrappings of the film-transport mechanism, seen in front of the primary mirror, have not been removed.

Sometimes it has been difficult for us here in Cambridge, where activity often reached hectic proportions, to keep in mind that MOONWATCH teams were not getting all the information they needed and deserved. In the future all observers should receive a substantially greater flow of the kind of data they require.

It should be borne in mind, however, that the original concept of our program still holds: that MOONWATCHERS carry on a diligent search on an emergency basis for a satellite immediately after its launching. This is particularly true for satellite rocket cases that do not carry radio broadcasting equipment. MOONWATCHERS are the only ones equipped to locate a new moonlet visually with "significant accuracy." Anyone can note a bright object crossing the sky and remark on its magnitude and speed, but only MOONWATCH can systematically, and on an acceptable basis, time its passage to a second and give its visual position to within a degree of arc.

A few teams somehow lost sight of this original intent and set up their equipment for observation only when they had been told, in effect, when and where to look. But there would be no point to our project if teams assembled to observe knowing in advance just where and exactly when to see a satellite. MOONWATCH is a "lost-and-found" operation that works hand in hand with the radio-tracking teams in the early stages of a satellite's life, and furnishes the essential information for photographic observations at our camera stations.

We at Smithsonian headquarters congratulate and thank the many MOONWATCH teams over the world who continue to furnish us, on a voluntary basis, data of considerable scientific value.

J. ALLEN HYNEK, Associate Director,
In Charge of Optical Tracking Program

MOONWATCH Observations

Since October 4, 1957, MOONWATCH teams have assumed the role of satellite trackers, providing almost daily reports on the Russian satellites 1957α and β. From these sightings it has been possible to keep these objects under observation and make predictions of their passages. In addition, these reports were used to predict the final plunges into the atmosphere of α1 and α2.

The observations furnished by our MOONWATCH stations were of unique value, especially when the radio signals from Sputnik I ceased three weeks after its October 4th launching, and from Sputnik II, a mere seven days after its birth on November 3rd. However, observations by radar could be made, which were a useful addition to the data provided by MOONWATCHERS.

As for the faint third component of the first Russian satellite — its nose cone, approximately nine sightings were reported from widely separated MOONWATCH stations. Without these the existence of α3 might never have been verified.

MOONWATCH observations have provided science with new knowledge of the upper atmosphere's density, particularly at around 150 miles. Computations derived from the visual trackings show that the density could be about five times greater than previously assumed.

It is a tribute to our MOONWATCHERS' observing skill that the number of observations of misidentified objects has been extremely small.

Usually a station can make only one observation during an observing session; however, several sightings may sometimes be achieved. Through December 31, 1957, 151 of 194 teams in the United States and foreign countries reported 1,506 scientifically usable observations of the 1957 Sputniks during 747 sessions.

Of the 115 teams in the United States, 91 stations held 434 observing sessions, amassing 994 sightings. The four Australian stations had 26 sessions with 91 observations. One of the three teams in Chile reported seven sightings on two occasions, and the MOONWATCH team in the Netherlands Antilles made one observation. During 284 sessions, 51 of the 71 stations in Japan obtained 413 sightings.

The following are U. S. stations which reported observations, with the total number of productive observing sessions through December 31st:

Station	*Code Number*	*Sessions*
Sylacauga, Ala.	001 033 086	3
Phoenix, Ariz.	002 033 112	4
Tucson, Ariz.	003 032 111	10
Altaville, Calif.	004 038 121	1
China Lake, Calif.	098 036 118	1
Los Altos, Calif.	005 037 122	5
Los Angeles, Calif.	100 034 118	7
Oakland, Calif.	006 038 122	9
Sacramento, Calif.	007 039 121	18
San Francisco, Calif.	008 038 122	3
Santa Barbara, Calif.	009 034 120	3
Stockton, Calif.	010 038 121	1
Sunnyvale, Calif.	078 037 122	1
Walnut Creek, Calif.	011 038 122	6
Whittier, Calif.	012 034 118	13
Denver, Colo.	013 040 105	7
New Haven, Conn.	087 041 072	8
Norwalk, Conn.	120 041 073	2
Washington, D. C.	014 039 077	8
St. Petersburg, Fla.	121 028 083	1
West Palm Beach, Fla.	016 027 080	9
Athens, Ga.	079 034 083	1
Hapeville, Ga.	017 034 084	1
Boise, Idaho	018 044 116	1
Idaho Falls, Idaho	019 043 112	7
Chicago, Ill.	085 042 088	1
Danville, Ill.	021 040 088	3
Lemont, Ill.	022 042 088	4
Peoria, Ill.	023 041 090	6
Rantoul, Ill.	092 040 088	2
Evansville, Ind.	094 038 088	2
Indianapolis, Ind.	024 040 086	1
Terre Haute, Ind.	025 039 087	4
Manhattan, Kans.	027 039 096	9
Wichita, Kans.	028 038 097	3
Wilmore, Ky.	029 038 085	2
New Orleans, La.	030 030 090	5
New Orleans, La.	031 030 090	5
Baltimore, Md.	088 039 077	3
Silver Spring, Md.	032 039 077	3
Cambridge, Mass.	099 042 071	23
Detroit, Mich.	033 042 083	2
St. Paul-Minneapolis, Minn.	035 045 093	5*
Biloxi, Miss.	090 030 089	3
Kansas City, Mo.	036 039 095	3
St. Louis, Mo.	080 039 090	4
Lincoln, Nebr.	038 041 097	4
Dover, N. J.	039 041 075	3
Paterson, N. J.	108 041 074	1
Red Bank, N. J.	040 040 074	5
Alamogordo, N. M.	102 033 106	1
Albuquerque, N. M.	041 035 107	10
Las Cruces, N. M.	042 032 107	6
Los Alamos, N. M.	043 036 106	8
Millbrook, N. Y.	045 042 074	5
New York City, N. Y.	046 041 074	2
Schenectady, N. Y.	081 043 074	4
Greensboro, N. C.	049 036 080	10
Cincinnati, Ohio	050 039 085	3
Cleveland, Ohio	052 042 082	1
Columbus, Ohio	051 040 083	1
Dayton, Ohio	082 040 084	5
North Canton, Ohio	053 041 081	6
Struthers, Ohio	075 041 081	1
Tulsa, Okla.	054 036 096	7
Lawton, Okla.	110 035 098	7
Portland, Ore.	076 045 123	6
Bryn Athyn, Pa.	055 040 075	13
Chambersburg, Pa.	056 040 078	1
Harrisburg, Pa.	057 040 077	2
Philadelphia, Pa.	058 040 075	1
Pittsburgh, Pa.	059 040 080	2
State College, Pa.	060 041 078	4
Yankton, S. D.	061 043 097	3
Bristol, Tenn.	097 037 082	5
Chattanooga, Tenn.	062 035 085	5
Amarillo, Tex.	064 035 102	6
Big Spring, Tex.	083 032 101	1
Bryan, Tex.	065 031 096	4
Edinburg, Tex.	066 026 098	7
El Paso, Tex.	104 032 106	1
Fort Worth, Tex.	068 033 097	6
Fort Worth, Tex.	069 033 097	5
San Angelo, Tex.	105 031 100	2
San Antonio, Tex.	089 029 098	5
Waco, Tex.	070 032 097	1
Waco, Tex.	093 032 097	2
Arlington, Va.	071 039 077	3
Fort Belvoir, Va.	077 039 077	7
Harrisonburg, Va.	072 038 079	4
Roanoke, Va.	073 037 080	5
Spokane, Wash.	086 048 118	3
Milwaukee, Wisc.	074 043 088	15

LEON CAMPBELL, JR.

XIV. Regions of Visibility of a Satellite After Launching

The first trip of a satellite in its orbit is, in some respects, its most important one. Amateur astronomers everywhere, and MOONWATCH teams in particular, would like to know the geographical areas of visibility of American satellites at the time of their initial trips around the world. Therefore, the table below has been compiled to show, with reference to the hour of launching, the times and areas where a United States satellite can be observed.

The table is calculated for the position of the sun on February 20th, but should hold approximately for a few weeks after that date. It is assumed that a satellite is launched at Cape Canaveral, Florida, in a direction slightly south of east. This places it in an orbit having an inclination of about 35 degrees to the plane of the earth's equator; once established, this inclination does not change. The period is taken to be 105 minutes, and the height of the satellite at the time of observation either 300 or 450 miles.

Morning and evening periods of visibility have been tabulated separately. The first two columns show the hour of launching in Eastern standard time and in Universal time. The third column gives the time in UT when the satellite is visible for the first time in the morning sky. The next four columns show the approximate latitude and longitude limits for visibility of the satellite, computed for heights of 300 and 450 miles. The eighth column gives the time interval between launching and the beginning of the period of visibility.

The remaining half of the table provides similar predictions for visibility during the early evening. If the time of launching occurs between two of the listed hours, then a linear interpolation will be accurate enough.

These limits of visibility have been predicted on the basis that the satellite will be bright enough to be seen at the end of nautical twilight in the evening and before it begins in the morning, that is, when the sun is more than 12 degrees below the horizon. If, however, the satellite were bright, the civil twilight limit (sun six degrees below the horizon) might be used, and the longitude limits would be several degrees wider. And for a body observable only after the end of astronomical twilight (sun 18 degrees below the horizon), the longitude limits will shorten by six degrees or more. In this last case, add at least six degrees to the smaller value of the two limits for the zone of morning visibility, and subtract six degrees or more from the greater value for the evening twilight period.

If the launching were to be at a greater or lesser inclination to the equator than the assumed 35 degrees, only the latitude limits would be affected. For a somewhat higher inclination, the limits of latitude can be increased toward the north and south poles; if the inclination is lower, the limits decrease. For a difference of five degrees, add or subtract the following amounts:

Mid-latitude of limits	0°	5°	10°	15°	20°	25°	30°	35°
Correction	0°	1°	2°	3°	3°	4°	5°	5°

Thus, for an inclination of 40 degrees, the correction increases the numerical values of both north and south latitudes. If the inclination is 30 degrees, the correction reduces them. For a change of other than five degrees in inclination, alter the correction proportionally.

Morning Period of Visibility

Launching Time EST	Launching Time UT	First Seen UT	HEIGHT = 300 Miles Latitude Limits	HEIGHT = 300 Miles Longitude West*	HEIGHT = 450 Miles Latitude Limits	HEIGHT = 450 Miles Longitude West*	Interval Min.
0	5	5:24	26S - 7S	2 - 16	30S - 3S	2 - 23	24
1	6	6:19	18S - 0	15 - 29	22S - 4N	15 - 37	19
2	7	7:15	10S - 12N	28 - 42	14S - 16N	28 - 50	15
3	8	8:10	1S - 21N	41 - 55	5S - 25N	41 - 63	10
4	9	9:05	8N - 28N	53 - 68	4N - 33N	53 - 77	5
5	10	10:00	16N - 36N	66 - 81	12N - 40N	66 - 90	0
6	11	12:42	20N - 42N	104 - 121	16N - 45N	104 - 130	102
7	12	13:38	22N - 45N	117 - 134	18N - 50N	117 - 144	98
8	13	14:35	24N - 45N	131 - 149	20N - 50N	131 - 159	95
9	14	15:31	25N - 45N	145 - 163	19N - 50N	145 - 173	91
10	15	16:27	22N - 41N	159 - 176	18N - 45N	159 - 186	87
11	16	17:23	16N - 38N	174 - 191	13N - 42N	174 - 201	83
12	17	18:18	10N - 32N	188 - 205	6N - 36N	188 - 215	78
13	18	19:13	1S - 22N	204 - 221	5S - 26N	204 - 230	73
14	19	20:05	13S - 12N	220 - 237	18S - 16N	220 - 247	65
15	20	21:00	25S - 2N	236 - 253	30S - 5N	236 - 265	60
16	21	21:54	33S - 7S	252 - 271	38S - 4S	252 - 283	54
17	22	22:50	38S - 15S	268 - 287	46S - 12S	268 - 299	50
18	23	23:45	43S - 20S	285 - 304	49S - 16S	285 - 315	45
19	24	0:41	45S - 22S	300 - 320	50S - 17S	300 - 330	41
20	1	1:38	43S - 22S	315 - 333	49S - 17S	315 - 343	38
21	2	2:34	40S - 20S	328 - 344	45S - 15S	328 - 354	34
22	3	3:31	36S - 18S	341 - 356	40S - 13S	341 - 5	31
23	4	4:28	32S - 13S	354 - 7	35S - 9S	354 - 16	28

Evening Period of Visibility

Launching Time EST	Launching Time UT	First Seen UT	HEIGHT = 300 Miles Latitude Limits	HEIGHT = 300 Miles Longitude West*	HEIGHT = 450 Miles Latitude Limits	HEIGHT = 450 Miles Longitude West*	Interval Min.
0	5	6:27	21N - 43N	160 - 177	16N - 48N	150 - 177	87
1	6	7:24	17N - 40N	174 - 190	13N - 44N	165 - 190	84
2	7	8:20	11N - 34N	186 - 202	7N - 37N	177 - 202	80
3	8	9:15	4N - 24N	201 - 215	0 - 29N	192 - 215	75
4	9	10:09	5S - 16N	213 - 227	9S - 20N	204 - 227	69
5	10	11:05	14S - 7N	225 - 239	18S - 11N	217 - 239	65
6	11	12:00	24S - 3S	237 - 250	27S - 2N	228 - 250	60
7	12	12:57	30S - 10S	248 - 262	35S - 5S	239 - 262	57
8	13	13:53	36S - 15S	258 - 273	42S - 10S	250 - 273	53
9	14	14:50	40S - 18S	268 - 286	47S - 13S	262 - 286	50
10	15	15:46	44S - 21S	283 - 300	50S - 20S	273 - 300	46
11	16	16:42	45S - 21S	296 - 314	50S - 20S	287 - 314	42
12	17	17:38	45S - 22S	309 - 328	50S - 20S	300 - 328	38
13	18	18:33	41S - 21S	325 - 345	48S - 17S	316 - 345	33
14	19	19:27	35S - 17S	343 - 2	41S - 10S	332 - 2	27
15	20	20:22	26S - 6S	358 - 17	32S - 1S	348 - 17	22
16	21	21:16	15S - 6N	16 - 33	21S - 10N	6 - 33	16
17	22	22:10	6S - 19N	33 - 50	10S - 23N	23 - 50	10
18	23	23:05	6N - 28N	49 - 66	2S - 33N	39 - 66	5
19	24	24:00	14N - 36N	64 - 80	9N - 40N	54 - 80	0
20	1	2:41	19N - 42N	104 - 121	15N - 45N	95 - 121	101
21	2	3:37	23N - 45N	118 - 136	19N - 50N	109 - 136	97
22	3	4:34	24N - 45N	132 - 150	20N - 50N	122 - 150	94
23	4	5:31	23N - 45N	146 - 163	19N - 50N	136 - 163	91

*Longitude is expressed as 0° to 360° in a direction westward from the Greenwich meridian.

A change of the satellite's initial period alters both the time and the limits of first visibility. The change in time is proportional to the change in the period, and the column giving the time interval may be adjusted accordingly. The effect on the latitude limits caused by a 10-minute change in period is insignificant, and the correction to the longitude limits is less than two degrees.

Observations of the satellite on its second and succeeding trips around the globe are possible at intervals of time approximately equal to the period of revolution, and for several days the limits of visibility in latitude change very little. But because the earth rotates under the satellite, each successive passage occurs farther to the west. Therefore, it is necessary to shift the initial-orbit longitude limits (given in the table) westward by a fixed amount, depending on the period, on succeeding revolutions of the satellite. These approximate values may be used:

Period in minutes	100	105	110	115
Longitude shift	25°.3	26°.6	27°.8	29°.0

GEORGE VEIS
Institute of Geodesy
Ohio State University

A Satellite Simulator

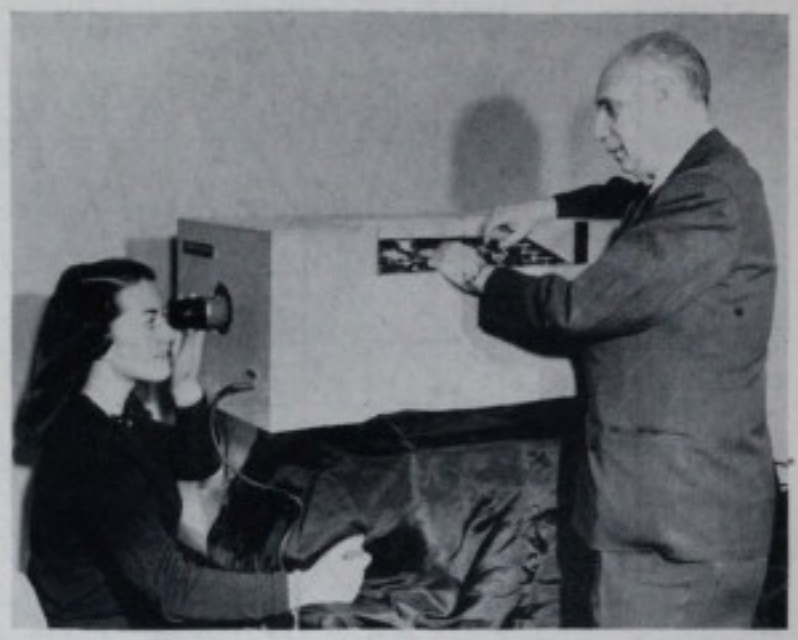
Simulated satellite passages for training purposes can now be produced with the aid of a special device that is being circulated among MOONWATCH teams in the United States. This simulator was built to MOONWATCH specifications by Jack A. Wegener, Gloucester City, New Jersey.

A flick of the switch and a twist of a knob will produce any type of satellite that is desired at any time. It can be bright or faint, slow or fast, against a bright twilight sky or almost in complete darkness, with or without a star background, and moving in almost any desired direction. For teams that use the vertical-mast method of observation, the moments of the satellite's disappearance behind the mast and reappearance into the field can easily be observed. For teams that use the star-map method, this type of position fixing can be practiced easily with the new device.

It was realized in the early days of MOONWATCH planning that neither practice flybys by Civil Air Patrol planes nor actual observing sessions with the first satellites would give all teams the necessary experience for tracking the rather faint object the first United States satellite turns out to be. It was necessary, therefore, to devise a method of imitating the characteristics of a faint satellite as well as the various observing conditions under which it would be seen.

Mr. Wegener's first instrument is now making the rounds of some MOONWATCH stations in the Southwest, on a schedule designed to conserve time in transit between stations and to hold shipping costs to a minimum. Two additional units, with modifications based upon experience with the first, will be delivered shortly. Ultimately, every team in this country will have used one of the simulators for training observers; thereafter it is planned to ship one of the instruments to a number of overseas stations.

In the comfort of indoors, an observer looks through the MOONWATCH telescope that is part of the simulator and watches the satellite cross the star field just as if he were observing outdoors. He signals the significant instants of observation to the operator, who records the results. By means of the controls the operator can vary the satellite's brightness from about zero to 8th magnitude, move the satellite in any direction at a variety of speeds from about one-fifth of a degree per second to about five degrees per second, and stop it at any point along its path. He can also vary the conspicuousness of



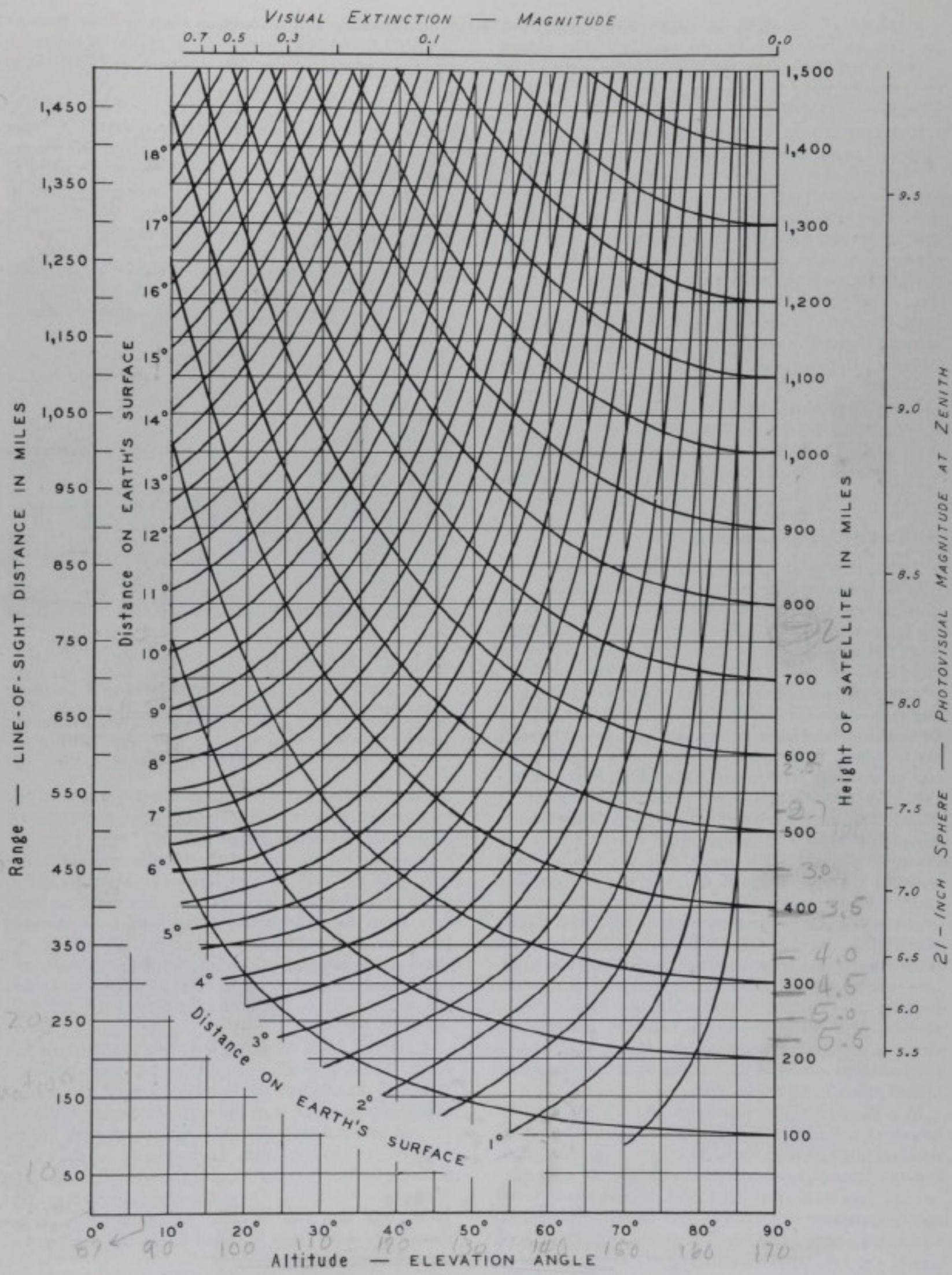
The satellite simulating device, built by Jack A. Wegener, is being tried out by Miss Rosemarie Sweeney, with Dr. Armand N. Spitz at the controls. In actual practice, the observer works under a light-tight hood unless the room is in complete darkness. This equipment was first exhibited by Mr. Wegener at the 1957 general convention of the Astronomical League at Kansas City, Missouri. Three such instruments will be used to train MOONWATCH observers.

the stars in the field, and change the brightness of the background itself to simulate different times during evening and morning twilight periods.

A number of members of the Cambridge, Massachusetts, MOONWATCH team, headed by Marshall Melin, tested the Wegener simulator and developed accurate data about the observability of satellites under varying conditions and with different observers. As soon as an observer has experienced several simulated satellite passages, his skill is greatly increased in locating a real satellite, particularly one of low brightness, in a MOONWATCH telescope.

A magnetic tape recording has been prepared, in two parts. The first is to be heard by an entire MOONWATCH team before the simulator is used, the second while each observer is at the eyepiece of the simulator. Printed information is also provided, concerning the instrument and its operation. In preparing the device for field use and developing its operational techniques, Mr. Melin was assisted by Dorothea and Russell Battersby, John Gray, and Paul Valleli. Alfred Moseley, an industrial psychologist, was consulted on the problems of physiological optics.

ARMAND N. SPITZ
Coordinator of Visual Observations



Instructions are given on the next page for using this diagram, by which a satellite observer can solve, by inspection, various problems involving the height, distance, angular elevation, and brightness of an artificial satellite.

XV. A Chart for Finding a Satellite's Distance and Elevation

Satellite observers often want to know the conditions of visibility for an object, yet do not have all the desired information. For example, an observer in Chicago may know that at a particular time a Russian artificial satellite is to pass directly over Pittsburgh, say, at a height of 500 miles. He wants to know how many degrees up the sky the satellite will appear from Chicago, how many miles away it will be at the time, and how bright it will look.

The graph on the facing page provides an easy way to obtain approximate answers to questions of this kind. On it are represented the four principal quantities involved in the geometry of satellite observations:

Height (in miles) of the satellite above the earth's surface.

Distance (in degrees) along the surface from the observer to the place where the satellite passes overhead (subsatellite point).

Range or line-of-sight distance from the observer to the satellite.

Altitude or angular elevation of the satellite above the observer's horizon.

Given any two of these quantities, the remaining two can be found from the graph. Perhaps the two most frequently known prior to making an observation are height and distance. They are represented on the graph by two families of heavy curved lines. The first, giving lines of equal distance to the subsatellite point, runs from lower left to upper right; the second, giving lines of equal satellite height, runs from lower right to upper left.

Therefore, in our Chicago-Pittsburgh example, the observer knows the height, 500 miles, and the approximate distance between the cities, 400 miles. The distance must be converted to degrees, one degree on the earth's surface being about 69 miles; therefore 400 miles is nearly 5.8 degrees. Read up the scale of heights on the right-hand edge of the graph to the line for 500-mile height; then follow this line to the left until its intersection with the other curved line representing six degrees of distance on the earth's surface (this is the twelfth line from the right in that family). It is easy to interpolate for the value 5.8 between the curves for 5.5 and six degrees. This point on the 500-mile height curve completely determines the situation geometrically.

Read vertically downward from this point to the scale at the bottom of the graph, where we see that the altitude of the satellite at Chicago will be about 47 degrees. Next read horizontally to the scale at the far left, where the range of the satellite is found to be about 660 miles. It should be possible to interpolate with similar accuracy at all points on the graph.

The chart also provides a means of estimating the apparent magnitude of a spherical satellite from its range and the altitude. At the observer's zenith, the apparent magnitude of a satellite illuminated by the sun when the latter is below the horizon depends principally on the height of the sphere, its diameter, and the reflectivity of its surface. Therefore, on the right side of the graph there is a scale showing the *photovisual magnitude* of a satellite at the zenith. This is evaluated for a 21-inch sphere of 80-per-cent reflectivity, about that of polished aluminum.

The observer will rarely see a satellite exactly in his zenith, however, so the magnitude scale must be corrected for the *extinction* or dimming by the atmosphere, which depends upon the altitude above the observer's horizon. This correction to the photovisual magnitude scale is shown at the top of the graph—for altitudes above 45 degrees it amounts to 0.1 magnitude or less and may be ignored for most purposes. For altitudes of less than 15 degrees, extinction increases rapidly and depends so much upon the condition of the atmosphere (haze, smoke, and the like) that magnitude predictions cannot be made with any reliability.

For spheres of other sizes than 21 inches, the correction to be added to the value given by the magnitude scale is given by the expression:

$$Correction = -5 \log (diameter/21),$$

where the diameter of the sphere is in inches. Here are some representative values:

Diameter in inches	6	30	60	120
Correction	+2.72	−0.77	−2.28	−3.78

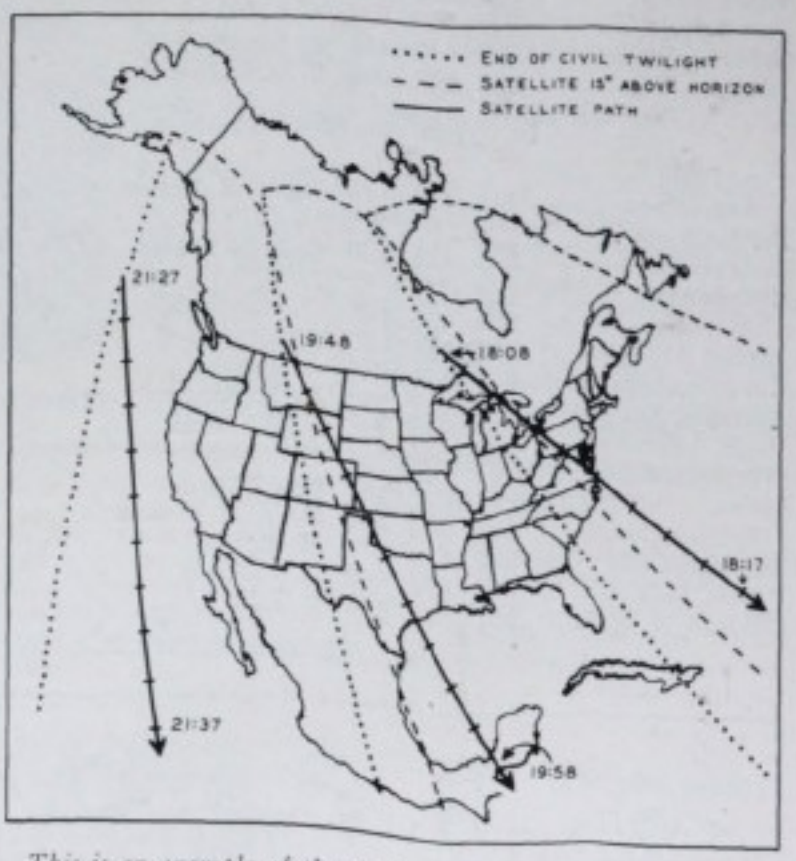
A second correction, to be added for a reflectivity different from 0.8, is

$$Correction = -2.5 \log (reflectivity/0.8).$$

Some typical values are:

Reflectivity	0.75	0.70	0.60	0.50
Correction	+0.07	+0.15	+0.31	+0.51

JACK W. SLOWEY



This is an example of the daily prediction chart released by Smithsonian headquarters to the press. It shows, for January 27, 1958, the observable passages of Sputnik II over North America. The heavy tracks have ticks marking the overhead point of the satellite for each minute. The times are Eastern standard. Note that the track beginning at 18:08 passes near Pittsburgh, Pennsylvania.

MOONWATCH TEAM REGISTRATIONS SINCE BULLETIN NO. 7

IN THE UNITED STATES:

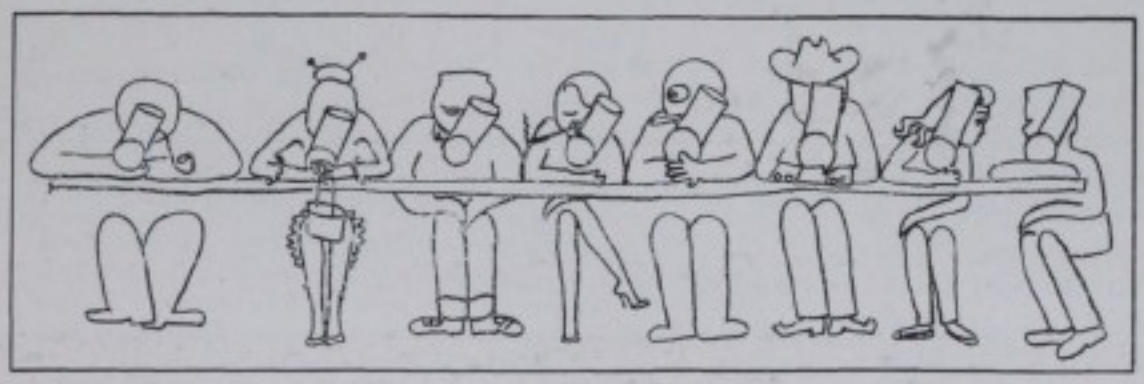
Location	*Code*	*Number*		*Leader*
Yuma, Ariz.	107	033	115	Capt. M. A. Raab
China Lake, Calif.	098	036	118	C. L. Evans, Jr.
Culver City, Calif.	119	034	119	R. A. Citron
Los Angeles, Calif.	100	034	118	C. Harris
Santa Monica, Calif.	109	034	119	R. N. Mayhew
Sunnyvale, Calif.	078	037	122	D. Worn
Van Nuys, Calif.	113	034	119	D. M. May
New Britain, Conn.	124	042	076	F. J. Rio
New Haven, Conn.	087	041	072	R. Brown
Norwalk, Conn.	120	041	073	H. W. Marshall, Jr.
Panama City, Fla.	091	030	086	1st Lt. G. O. Bertram
St. Petersburg, Fla.	121	028	083	A. W. Gay
Chicago, Ill.	085	042	088	J. Caplan
Rantoul, Ill.	092	040	088	Lt. Col. D. D. Suttle
Evansville, Ind.	094	038	088	Prof. R. T. Dufford
Baltimore, Md.	088	039	077	Dr. Sally H. Dieke
Cambridge, Mass.	099	042	071	M. Melin
Biloxi, Miss.	090	030	089	Capt. R. J. Spence
Clinton, Miss.	111	032	090	Prof. H. A. Carlock
St. Louis, Mo.	080	039	090	S. L. O'Byrne
Paterson, N. J.	108	041	074	M. Waldstein
Alamogordo, N. M.	102	033	106	E. P. Martz, Jr.
Cary, N. C.	112	036	079	R. Philbrick
Dayton, Ohio	082	040	084	K. E. Kissell
Struthers, Ohio	075	041	081	J. S. Gomochak, Jr.
Lawton, Okla.	110	035	098	M. Shaw, Jr.
Portland, Ore.	076	045	123	R. L. Boardwell
Bristol, Tenn.	097	037	082	Prof. E. W. Burke, Jr.
Memphis, Tenn.	123	035	090	A. F. Clay
Big Spring, Tex.	083	032	101	E. B. McCormick
Dodson, Tex.	084	035	100	T. E. Lennon
San Angelo, Tex.	105	031	100	Maj. A. Flynn
San Antonio, Tex.	089	029	098	Dr. P. L. Seabase
San Antonio, Tex.	096	030	098	2nd Lt. C. A. Blocker
San Antonio, Tex.	125	029	099	Maj. F. W. Miller
Waco, Tex.	093	032	097	Lt. F. J. McGouldrick, Jr.
Fort Belvoir, Va.	077	039	077	A. L. White
Spokane, Wash.	086	048	118	R. Caputo
Madison, Wisc.	122	043	089	S. M. Robinson

IN OTHER COUNTRIES:

Pago Pago, Am. Samoa	118	104	170	Dr. W. R. Kellen
Buenos Aires, Argentina	800	125	058	C. L. M. Segers
Buenos Aires, Argentina	801	125	058	O. Piacquadio
Merlo, Argentina	802	125	059	A. E. Leiva
Cordoba, Argentina	803	121	064	A. Fazio
Adelaide, Australia	600	125	319	R. L. Sangster
Perth, Australia	601	122	296	R. W. Boggis
Woomera, Australia	603	121	216	F. I. Mentha
Lwiro, Belgian Congo	400	092	209	Dr. A. H. Delsemme
Santiago, Chile	805	124	071	G. Romero
Puebla, Mexico	900	019	098	D. Taboada
Curacao, N. W. I.	901	012	069	L. Telle
Arequipa, Peru	807	106	072	L. G. Paredes
Montevideo, Uruguay	808	125	056	H. F. Guido
Quezon City, Philippines	500	015	301	E. Calpo
Bloemfontein, S. Africa	401	119	206	G. N. Walker
Cape Town, S. Africa	402	124	198	W. P. Hirst

IN JAPAN:

Akita	200	040	320	I. Shinjo
Ashiya	202	035	315	T. Shibata
Atsuta	260	035	317	A. Goto
Chiba	261	036	320	K. Sugiyama
Chunichi	204	035	317	M. Nakashima
Fuchu	214	035	313	H. Nojima
Fukuoka II	206	034	310	T. Sakanoue
Fukuoka III	207	034	310	T. Sakanoue
Higashimatsuyama	210	036	319	Y. Tsuchida
Himeji	262	035	315	S. Kuwahara
Hofu	213	034	312	K. Suga
Honjo	212	036	319	S. Sasagawa
Kagoshima	218	032	311	S. Yamaguchi
Kanagawa	219	035	319	S. Kazama
Kanazawa	221	037	317	C. Koikeda
Kasukabe	263	036	320	J. Senzaki
Kiru	223	036	319	H. Muramatsu
Kochi	264	034	314	S. Yamamoto
Kumamoto	225	033	311	S. Mitsushima
Kure	226	034	313	S. Hayashi
Kureme	265	033	311	K. Iwanaga
Kyoto	259	035	316	S. Fuzisawa
Manazuru	228	035	319	Y. Inoue
Mie	266	035	317	E. Itami
Mitaka	229	036	320	
Miyazaki	230	032	311	M. Inaba
Mizukaido	231	036	320	N. Hamana
Mizusawa	267	039	321	T. Ikeda
Mount Fuji	232	036	319	
Mount Fuji	273	035	319	
Nagano	234	036	318	N. Kobayashi
Nagasaki	268	033	310	T. Ishii
Oita	239	034	311	S. Abe
Osaka	240	035	316	C. Noda
Osaka-Yomiuri	241	035	316	T. Takagi
Otaru	243	043	321	K. Hayakawa
Otsu	269	035	316	M. Morikawa
Saga	244	033	310	T. Koga
Sapporo	245	043	321	H. Fukushima
Sendai	252	038	321	T. Kuze
Takada	250	037	318	S. Kurihara
Takaoka	270	037	317	M. Tsuda
Tokushima	253	034	315	K. Kiba
Toyama	254	037	317	K. Kuratani
Utsunomiya	271	037	320	Y. Funada
Yamagata	257	038	320	H. Soma
Yatsushiro	272	033	311	T. Fujikado



This cartoon is reproduced from the "Great Plains Observer," edited by Walter Scott Houston. Its caption reads: "The thing about MOONWATCH that intrigues us is the considerable range of society it draws from. Old men shiver, junior high kids romp, local bankers rub elbows with the guy who sweeps out the bank."

★ ★ TRECKERSCOPE ★ ★

TRECKERSCOPES (from left to right) — 12½" DE LUXE, 10" DE LUXE, 8" DE LUXE, 6" DE LUXE, and 10" CASSEGRAIN "SKY-GIANT"

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" 12½"	1150.00	" 12½"	995.00
10" CASSEGRAIN "SKY-GIANT"	$1695.00		

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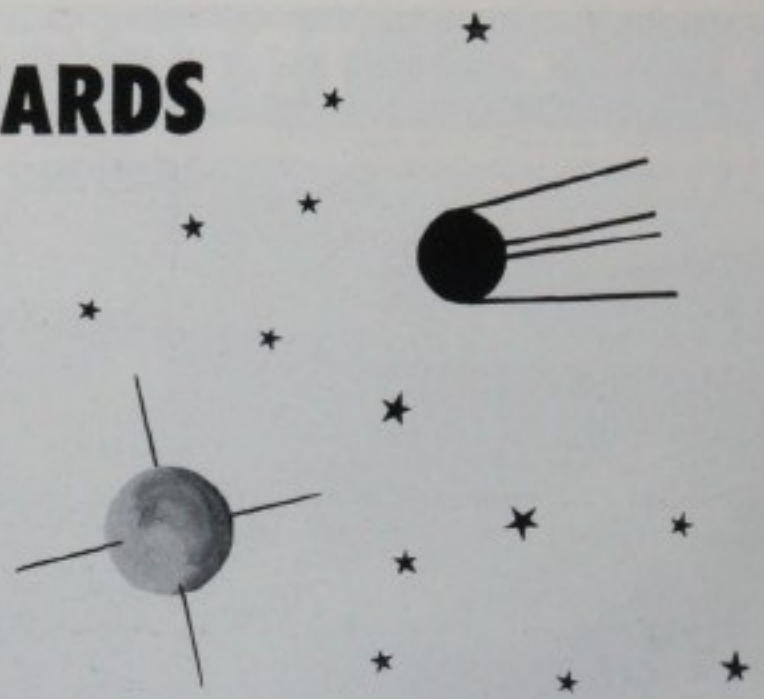

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They are of two types: the GOTOSCOPE SUPER and the GOTOSCOPE JUNIOR

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Amateur Photoelectric Photometry of Comet Arend-Roland

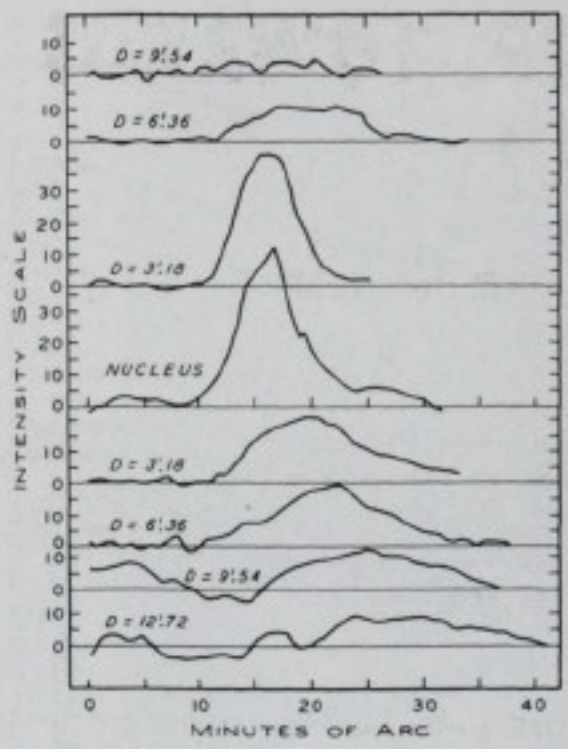
THREE French amateurs, Robert Meunier, Jean Pierre Legrand, and Michel Bonpas, have reported their photoelectric photometry of Comet 1956h in the October, 1957, issue of *l'Astronomie*. Not only did they determine the brightness of the nucleus in blue and yellow light, but they made sweeps across the comet at different distances from the head, recording the large-scale structure of the tail.

Their apparatus was mounted on a 8-inch equatorial refractor. The photometer objective was 78 millimeters in diameter, with a focal length of 54 centimeters. A screen at its focal plane had a one-millimeter hole to transmit light to an RCA 931A photomultiplier tube, the observed sky area being 6.4 minutes of arc in diameter.

Blue and yellow filters were used to limit the spectral response of the photomultiplier, giving photographic and photovisual magnitudes. The output of the tube was fed to a direct-current amplifier, the amplified current then being read on a sensitive galvanometer. A radioactive light source was used to check the stability of the apparatus. Variation in output of the photometer due to internal causes was about ±6 per cent.

Stars of known brightness were used to calibrate the actual observations, and the effects of changes in brightness of the sky background had to be taken into account. On April 28th the blue and yellow magnitudes of the comet's nucleus were 4.34 and 3.65, respectively. Visual observers had reported Comet Arend-Roland to be golden in color. On May 1, 1957, the blue was 5.0 and the yellow was 4.5. By May 22nd the blue was 8.0, but the yellow was not measured. All these measures had an accuracy of about ±0.1 magnitude.

Sweeps with the photometer across the nucleus, head, and tail structure of the comet in blue light on May 1st gave records shown by the graph. The upper part is the region toward the sun from the comet's nucleus, and indicates the remnants of the famous sunward spike of



Photoelectric sweeps across Comet 1956h on May 1, 1957. From the French journal "l'Astronomie."

Comet Arend-Roland. The lower part of the chart indicates some of the coarser features of the tail within 13 minutes of the nucleus.

ED. NOTE: The construction of photoelectric apparatus for the amateur is described in the AAVSO manual compiled by Lewis J. Boss, as noted on page 21 of *Sky and Telescope* for November, 1957. Also, see page 287, *Amateur Telescope Making – Book Three*, for an article by Gerald E. Kron on direct-coupled amplifiers for use with stellar photoelectric photometers.

VENUS' MARKINGS

In the discussion on the illusory markings of Venus on page 588 of last October's *Sky and Telescope*, and in Patrick Moore's letter on page 179 of the February issue, there is mention of the pattern of dark radial spokes on the surface of that planet reported by Percival Lowell.

Until the 1955 publication of Audouin Dollfus' Venus drawings in the French journal *l'Astronomie*, I had doubted the reality of this wheel-like appearance. One of these drawings, reproduced on page 397 of the July, 1956, *Sky and Telescope*, has a curious pattern of radial streaks, strongly resembling those in pictures by Lowell. Only Dollfus made the spokes much broader and rather diffuse. His work was carried out at Pic du Midi Observatory with a fine 24-inch refractor and powers always over 500x, under very favorable conditions. So one might consider these drawings a valuable corroboration of Lowell's observations of the radial Venus markings.

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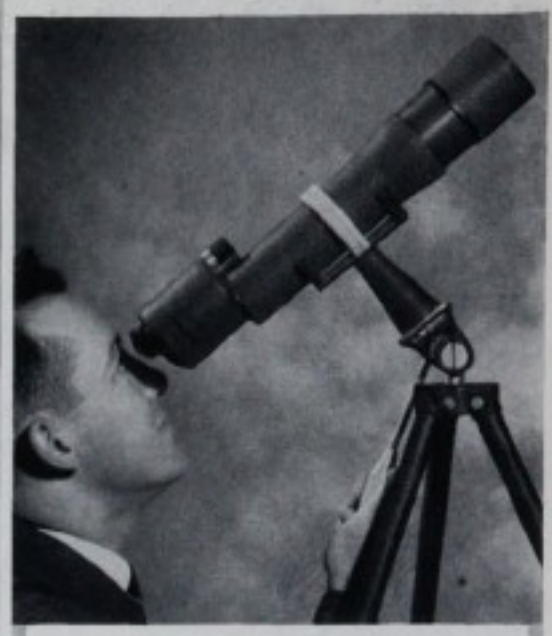

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NOTE ON THE UNITRON 6"

Observers who have noted the absence of the new UNITRON 6" Refractor from these pages will be pleased to learn that a full description and price schedule will appear next month. The many novel features of this unique model will be illustrated in complete detail. We believe that all telescope enthusiasts will find this of interest whether or not they are ready for an instrument of this size.

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See the back cover.

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BOOKS AND THE SKY

THE GALACTIC NOVAE

Cecilia Payne-Gaposchkin. Interscience Publishers, Inc., New York, 1957. 336 pages. $8.50.

A FAMOUS SCIENTIST once wrote, "The tendency of real science is ever towards simplicity. . . . True progress consists quite as much in the more complete assimilation of the old, as in the accumulation of new facts and inferences which in many cases ought to be regarded rather as the raw materials of science than as science itself."

On this definition alone, *The Galactic Novae* represents a significant advance in its field, for although a considerable amount of original work is in evidence, this volume is primarily an attempt to bring together and co-ordinate the known data on novae and related objects. Mrs. Payne-Gaposchkin has not only succeeded in this sense, but through judicious organization and emphasis has given the work considerable merit of its own.

The organization of the book is as follows. In seven chapters, the author discusses the statistics, distribution, and behavior of ordinary novae, and reviews the information available on each known specimen. She also devotes chapters to the U Geminorum and Z Camelopardalis variables and to the symbiotic stars. A highlight of the volume is the chapter on supernovae, which may serve to stimulate activity in a field that is in acute need of renewed attention. A final chapter deals with "Evolutionary and Theoretical Problems." It is natural that a survey of this kind, involving as it does the digestion of a large amount of varied information, bears unmistakable signs of the surveyor's own tastes, but Mrs. Payne-Gaposchkin has presented the subject with balance and fairness.

The subject of the ordinary novae seems almost a classical one. Over the past few decades new novae have been studied, significant observations made, and details clarified, but there have been very few basic advances and no major upheavals. Is any branch of modern astrophysics, however, so far advanced as to be essentially static, with no surprises left? It is fortunate that a book on the novae should appear at a time when there is such a promising outlook for important advances from new techniques and new points of view. This book may have the effect of igniting the subject again, perhaps in some quite unforeseen way.

In this volume, whose layout and general appearance are excellent, there are an irritating number of minor misprints. The worst example is probably on page 2, where all 22 page references are incorrect.

The Galactic Novae can be recommended as a thorough, authoritative, and readable account of the present state of its subject. It will certainly remain a standard reference work for many years, and is a promising first volume in the publishers' series in astrophysics.

G. H. HERBIG
Lick Observatory

THE OXIDATION AND WEATHERING OF METEORITES

John Davis Buddhue. University of New Mexico Press, Albuquerque, 1957. 161 pages. $1.75, paper bound.

LIKE his earlier volume, *Meteoritic Dust*, this latest monograph by Mr. Buddhue is bound to stimulate greater activity in meteoritics. While there have been only a few extensive research papers on the oxidation of meteorites, the rich bibliography of 225 references given in this book indicates that the subject has not been neglected. On the other hand, little has heretofore been done to bring the isolated bits of evidence and research together to form one systematic picture.

Relatively few meteorites have actually been seen to fall. Hence most of the statistics on the frequencies of meteorites have had to depend on finds whose ages are at best problematical. It is therefore important to know the rate and extent of the deterioration of such bodies, if only

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to estimate the rate of meteoritic accretion to the earth's mass. To this specific problem the author devotes little space, although he does mention the almost complete absence of meteorites in sediments older than the Pleistocene period of the earth's history.

Mr. Buddhue's primary purpose is to ascertain the effects of air, water, erosion, and other factors on meteorites. This he accomplishes both from chemical analyses of actual specimens and through laboratory experiments. In all, he has analyzed or discussed meteorites from 70 different falls or finds, representing a wide variety of meteorite types and impact terrain. We learn of shale balls, meteorodes (analogous to geodes but with meteoritic cores), and paleometeorites, explained more understandably than in previous books on meteoritics.

Moisture and air are the most important factors in the disintegration of meteorites. While the chief source of the modification of iron meteorites is rusting, iron oxide itself is stable and should ordinarily be preserved for millions of years. In view of the hazards of natural exposure, it comes as a shock that samples in museums may deteriorate even faster than others left in their places of fall. The author calls attention to the Cranbourne, Australia, meteorite of 8,200 pounds, deposited in the British Museum. There it rusted at a rate of four pounds a year, accumulating 200 pounds of rust before the process was halted by placing the meteorite in a sealed chamber under a stream of dry nitrogen.

Those who have looked upon the presence of nickel in objects suspected of meteoritic origin as almost certain proof, may be surprised by the evidence that nickel may be leached out of an oxidized specimen into the surrounding soil. Analyses of the soil have shown nickel content decreasing radially outward from a large meteorite. The age of a meteorite might even be estimated from the distribution of the trace amounts of nickel in the surrounding soil. By this method L. La Paz has estimated the age of the Brenham meteorites as 637,000 years. While no meteorite has been found completely lacking in nickel, this limiting possibility does exist. Absence of nickel can therefore no longer be considered positive proof that an object is not a meteorite or paleometeorite.

To derive the maximum benefit from the present monograph, the reader should be familiar with chemical and mineralogical terminology. The booklet has one unfortunate disadvantage common to many scientific papers: It lacks literary style. The author refers to himself excessively as "the writer" — 60 times in 50 randomly selected consecutive pages, sometimes as often as four times on a single page. The use of the simple "I" would have decreased the size of the book by more than half a page! Moreover, simple changes of sentence structure could often have avoided the use of any personal expression without the risk of sacrificing the scientific credit due the author.

Notwithstanding its literary deficiencies, *The Oxidation and Weathering of Meteorites* is a valuable contribution to the science of meteoritics.

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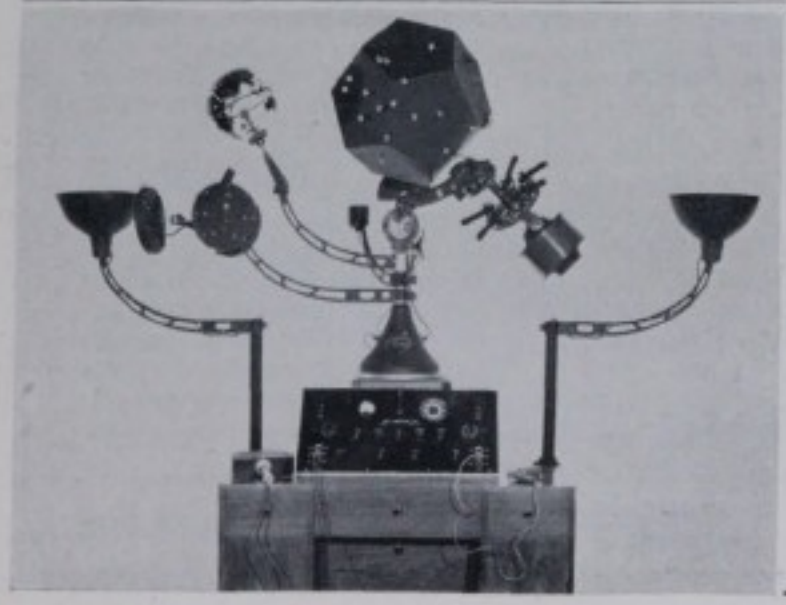

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AND THERE WAS LIGHT

Rudolf Thiel. Alfred A. Knopf, Inc., New York, 1957. 415 pages. $6.95.

WITHIN the past 10 years a gap in the literature of science has been filled by several good books that deal in a general way with astronomical history. Among these books are Abetti's *History of Astronomy*, Doig's *Concise History of Astronomy*, and de Vaucouleurs' *Discovery of the Universe*. Fortunately for the omnivorous reader, each of these treats the great astronomical discoveries in a different way.

And There Was Light, which is translated from the German by Richard and Clara Winston, utilizes still another approach. It puts the emphasis on the personal element, containing character sketches, colorful anecdotes, and imaginative accounts of the work of great astronomers. Beginning with ancient times and ending with space travel, the

major events are described in an easy and pleasant style.

Anecdotes that have no basis in fact often die hard. Authors find it difficult to resist repeating them. On page 91 it is said that Copernicus never saw the planet Mercury, a statement that Edward Rosen discounted long ago (*Sky and Telescope*, May, 1943, page 5). This legend is in a class with Parson Weems' cherry-tree tale.

On the other hand, the book's more flexible approach permits the proper emphasis on certain aspects of astronomy where other histories and textbooks fail. Surely, it was significant when the concept was first enunciated that the stars are suns, by Giordano Bruno; this concept was never quite grasped by Copernicus and never fully accepted by Kepler. One looks in vain for direct mention of this event in current general textbooks and histories of astronomy. However, Thiel's glowing tribute to the ideas of Bruno places them in their proper historical perspective.

Many of the lesser known names in astronomy are discussed. We read of Wegener's work on theories of the origin of lunar features, and there is an account of de la Rue's photographic display at the 1862 world exhibition in London. In a section entitled, "The American Spirit," there are some interesting details concerning Henry A. Rowland, Samuel P. Langley, and R. W. Wood. Of A. A. Michelson, Thiel states, "He loved his instruments as if they were beautiful women, maintaining that they had human characters, and distinctly feminine ones at that."

Many of the 54 well-reproduced photographs have appeared in other books, but some of the 73 line drawings will not be so familiar, having been taken from ancient woodcuts and engravings.

There are minor inconsistencies. For instance, Jupiter is said to have 11 moons on page 288, but has the correct number, 12, in the appendix. Thiel states of William Herschel, "He did not sit at the telescope in order to make measurements, but only to search for new bodies," on page 226, but three pages later, "Everything that Herschel undertook he pursued on the same grand scale. Since the height of the mountains of the Moon interested him, he measured more than one hundred lunar craters, making each measurement by three different methods."

The most unusual feature of this book is its striking use of words. Meteors are "cosmic gnats." Spectral lines, because of the Doppler effect, are "stellar speedometers." Rapidly rotating stars with thin gaseous rings are "Saturn suns."

For its freshness of presentation and its vivid style, *And There Was Light* is entertaining reading for all who are interested in astronomy.

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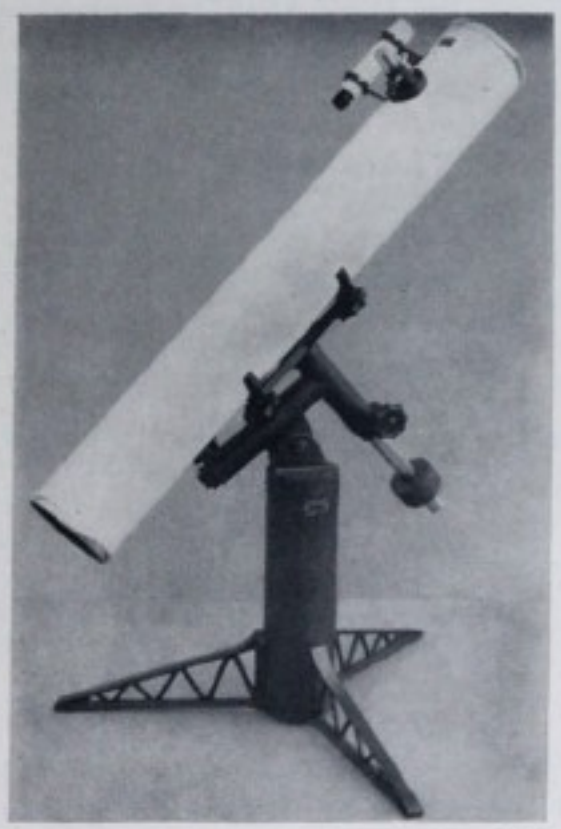

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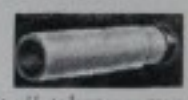

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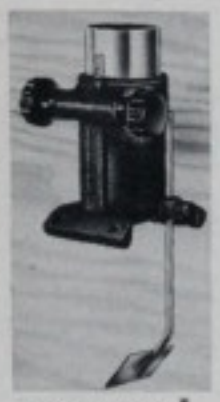

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HUYGENS TYPE — STANDARD 1¼" DIAMETER
6-mm. (¼") Focal Length
Stock #30,063-Y.....$8.50 ppd.

12.5-mm. (½") Focal Length
Stock #30,064-Y.....$8.00 ppd.

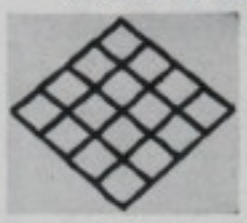
COMBINATION EYEPIECE — 10-mm. and 20-mm.
Stock #30,065-Y.....$9.00 ppd.

7X FINDER TELESCOPE–ACHROMATIC

Stock #50,080-Y Finder alone, less ring mounts...$9.95
Stock #50,075-Y Ring mounts per pair.....$3.95

RUBBER PITCH-LAP MAT

Saves Mirror Makers Time and Trouble

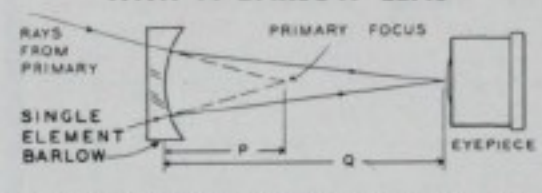


A rubber pitch-lap mat is used for forming the pitch-lap channels. Just pour the melted pitch on the tool, lay the mat on top and then press it in with your mirror to form the channels. When the pitch sets, an easy pull will remove the mat. In minutes instead of hours you are ready to polish. Eliminates time-consuming and tedious hand-cutting of the channels of the pitch lap.

All those disappointing break outs of the pitch, common when hand-cutting the channels, are avoided. You no longer have to pour and cut two or three laps before getting a usable one. With our Rubber Pitch-Lap Mat you can use the first one you make.

Stock No.	Size	For Mirror Diam.	Price ppd.
50,171-Y	13½" x 13½"	8", 10", 12"	$2.00
60,061-Y	6" x 6"	4¼", 6"	1.00

DOUBLE AND TRIPLE YOUR TELESCOPE'S POWER WITH A BARLOW LENS



WHAT IS A BARLOW? A Barlow lens is a negative lens used to increase the power of a telescope without resorting to short focal length eyepieces, and without the need for long, cumbersome telescope tubes. Referring to the diagram above, a Barlow is placed the distance P inside the primary focus of the mirror or objective. The Barlow diverges the beam to a distance Q. This focus is observed with the eyepiece in the usual manner. Thus, a Barlow may be mounted in the same tube that holds the eyepiece, making it very easy to achieve the extra power. The new power of the telescope is not, as you might suppose, due to the extra focal length given the objective by the difference between P and Q. It is defined as the original power of the telescope times the quotient of P divided into Q.

Beautiful chrome mount. We now have our Barlow lens mounted in chrome-plated brass tubing with special spacer rings that enable you to vary easily the power by sliding split rings out one end and placing them in other end. Comes to you ready to use. Just slide our mounted-lens into your 1¼" I.D. tubing, then slide your 1¼" O.D. eyepieces into our chrome-plated tubing. Two pieces provided, one for regular focal length eyepieces and one for short focal length ones.

Remember, in addition to doubling and tripling your power, a Barlow lens increases your eye relief and makes using a short focal length eyepiece easier.

Don't fail to try one of these. Many people do not realize the many advantages of a Barlow and the much greater use they can get from their telescopes. Our Barlow has a focal length of −1-5/16". We have received many complimentary letters about this lens. So sure are we that you will like it that we sell it under a 30-day guarantee of satisfaction or your full purchase price returned — no questions asked. You can't lose, so order today.

Stock #30,200-Y Mounted Barlow lens.....$8.00 ppd.

OPTICAL IDEA & GADGET CONTESTS

In celebration of International Geophysical Year—

First Contest Ends April 30, 1958

Second Contest Ends Dec. 31, 1958

Our Catalog has full details on rules, prizes and entry blank — Write for Catalog "Y."

BRASS TUBING

2 pieces, 3" long, slide fitting. Blackened brass. I.D. 1-3/16", O.D. 1-5/16".
Stock #40,165-Y.....$1.75 ppd.

30-day Money Back Guarantee as with all our Merchandise!

PRISM STAR DIAGONAL

For comfortable viewing of the stars near the zenith or high overhead with refracting telescopes using standard size (1¼" O.D.) eyepieces, or you can make an adapter for substandard refractors. Contains an excellent quality aluminized right-angle prism. Tubes are satin chrome-plated brass. Body is black wrinkle cast aluminum. Optical path of the system is about 3½".

Stock #70,077-Y.....$12.00 ppd.

SPITZ MOONSCOPE

A precision-made 32-power reflecting telescope — by makers of Spitz Jr. Planetarium. Clearly reveals the craters of the moon, shows moons of Jupiter, other wonders of the heavens. Based on same principles as world's giant telescopes. Stands 36" high on removable legs. Adjustable 3" polished and corrected mirror. Fork-type altazimuth mount rotates on full 360° circle — swings to any location in the sky. Fascinating 18-page instruction book, sturdy carrying case.

Stock #70,068-Y.....$14.95, ppd.

"MAKE-YOUR-OWN" 4¼" MIRROR KIT

The same fine mirror as used in our telescopes, polished and aluminized, lenses for eyepieces, and diagonal. No metal parts.

Stock #50,074-Y.....$16.25 ppd.

6X FINDER TELESCOPE

Has crosshairs for exact locating. You focus by sliding objective mount in and out. Base fits any diameter tube — an important advantage. Has 3 centering screws for aligning with main telescope. 20-mm. diam. objective. Weighs less than ½ pound.

Stock #50,121-Y.....$8.00 ppd.

MISCELLANEOUS ITEMS

KELLNER EYEPIECE — 2" focal length (1¼" O.D.). Mount of black anodized aluminum.
Stock #30,189-Y.....$6.00 ppd.

60° SPECTROMETER PRISM — Polished surfaces 18-mm. x 30-mm. — flat to ½ wave length.
Stock #30,143-Y.....$8.25 ppd.

ASTRONOMICAL TELESCOPE TUBING

Stock No.	I.D.	O.D.	Lgth.	Description	Price
80,038-Y	4⅞"	5¼"	46"	Spiral-wound paper	$2.50
85,008-Y	6⅞"	7⅜"	60"		4.00
85,011-Y	2⅞"	3"	48"	Aluminum	6.00
85,012-Y	3⅞"	4"	60"		8.75
85,013-Y	4⅞"	5"	48"		9.00
85,014-Y	6⅞"	7"	60"		15.00

All tubing is shipped f.o.b. Barrington, N. J.

BE SURE TO GET FREE CATALOG "Y"

Fantastic variety — never before have so many lenses, prisms, optical instruments, and components been offered from one source. Positively the greatest assembly of bargains in all America. Imported! War Surplus! Hundreds of other hard-to-get optical items. Write for Free Catalog "Y."

ORDER BY STOCK NUMBER . . . SEND CHECK OR MONEY ORDER . . . SATISFACTION GUARANTEED!

BARRINGTON • NEW JERSEY

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MOUNTED IN ALUMINUM CELLS f/15

We offer the lowest priced, hand-corrected, precision, American-made astronomical objective, *mounted in a black-anodized aluminum cell*. Our reputation has been established over the years as the most reliable source of high quality astronomical lenses.

"Those in the know" BUY FROM US BECAUSE:

Each lens is thoroughly tested by us and is guaranteed to resolve two seconds of arc or better. They are corrected for the C and F lines (secondary chromatic aberration). The zonal spherical aberration and the chromatic variation of spherical aberration are negligible. The cell is machined to close tolerances so that it will fit directly over our standard aluminum tubing, eliminating any mounting problems.

3¼" diam., 48" f.l. (uncoated) **$28.00**
Same as above with coating **$32.00**
4⅛" diam., 62" f.l. (uncoated) **$60.00**
Same as above with coating **$69.00**

We can supply ALUMINUM TUBING for the above lenses.

"BIG" ACHROMATIC TELESCOPE OBJECTIVES

We have the largest selection of diameters and focal lengths in the United States available for immediate delivery. These are perfect magnesium-fluoride coated and cemented Gov't. surplus lenses made of finest crown and flint optical glass. Not mounted. Fully corrected. Tremendous resolving power. They can readily be used with eyepieces of only ¼" focal length, thereby producing high powers. Guaranteed well suited for astronomical telescopes, spotting scopes, and other instruments. Gov't. cost up to $100.

Diameter	Focal Length	Each	Diameter	Focal Length	Each
54 mm (2⅛")	254 mm (10")	$12.50	83 mm (3¼")	660 mm (26")	$28.00
54 mm (2⅛")	300 mm (11.8")	12.50	83 mm (3¼")	711 mm (28")	28.00
54 mm (2⅛")	330 mm (13")	12.50	83 mm (3¼")	762 mm (30")	28.00
54 mm (2⅛")	390 mm (15.4")	9.75	83 mm (3¼")	876 mm (34½")	28.00
54 mm (2⅛")	508 mm (20")	12.50	83 mm (3¼")	1016 mm (40")	30.00
54 mm (2⅛")	600 mm (23½")	12.50	102 mm (4")	876 mm (34½")	60.00
54 mm (2⅛")	762 mm (30")	12.50	108 mm (4¼")	914 mm (36")	60.00
54 mm (2⅛")	1016 mm (40")	12.50	110 mm (4⅜")*	1069 mm (42-1/16")	60.00
54 mm (2⅛")	1270 mm (50")	12.50	110 mm (4⅜")	1069 mm (42-1/16")	67.00
78 mm (3-1/16")	381 mm (15")	21.00	128 mm (5-1/16")*	628 mm (24¾")	75.00
80 mm (3⅛")	495 mm (19½")	28.00	128 mm (5-1/16")	628 mm (24¾")	85.00
81 mm (3-3/16")	622 mm (24½")	22.50	*Not coated		

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COATED BINOCULARS

American Type "Zeiss" Type

Beautiful imported binoculars, precision made, at a low, low price. Above we have pictured the two most popular types. The American Type offers a superior one-piece frame and a clean design, pleasing to the eye. Complete with carrying case and straps. **Price plus 10% Federal tax.**

SIZE	TYPE	C. FOCUS	IND. FOCUS
6 x 15	OPERA	—	$12.75
6 x 30	"ZEISS"	$18.75	16.75
7 x 35	"ZEISS"	21.25	19.25
7 x 35	AMERICAN	23.50	—
7 x 35	AMERICAN WIDE ANGLE 10°	37.50	—
7 x 50	"ZEISS"	24.95	22.50
7 x 50	AMERICAN	32.50	—
8 x 30	"ZEISS"	21.00	18.25
10 x 50	"ZEISS"	30.75	28.50
20 x 50	"ZEISS"	41.50	39.50

MONOCULARS

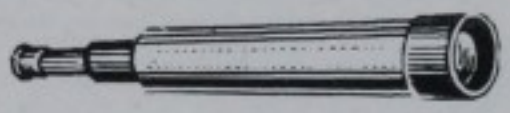
Brand new, coated optics, complete with pigskin case and neck straps.

	Price		Price
6 x 30	$10.00	7 x 50	$15.00
8 x 30	11.25	16 x 50	17.50
7 x 35	12.50	20 x 50	20.00

"MILLIONS" of Lenses, etc. Free Catalogue

We pay the POSTAGE — C.O.D.'s you pay postage. Satisfaction guaranteed or money refunded if merchandise returned within 30 days.

"GIANT" 3" TELESCOPE



40 power Special Price **$57.50**

Never before has anything like this been offered at so low a price. Here is another example of American ingenuity. Big 3" diameter achromatic coated objective which will give needle-sharp crystal-clear images. Focusing is a delight with the micrometer spiral focusing drawtube. Light-weight aluminum construction throughout, black crackle finish, length open 22 inches, closed 17 inches. This telescope gives an upright image — it is WONDERFUL for astronomy, SUPERB for long distances, EXCELLENT as a spotting scope.

"GIANT" EYEPIECE

WIDE ANGLE ERFLE (68° Field) **EYEPIECE.** Brand new; coated 1¼" E.F.L. Focusing mount, 5 perfect achromats, 1-13/16" aperture **$18.50**

WIDE ANGLE ERFLE 1½" E.F.L. Brand new; contains Eastman Kodak's rare-earth glasses; aperture 2"; focusing mounts; 65° field **$18.50**

1¼" Diam. Adapter for above eyepieces **$3.95**

LENS CLEANING TISSUE — Here is a wonderful Gov't. surplus buy of Lens Paper which was made to the highest Gov't. standards and specifications. 500 sheets size 7½" x 11" **$1.00**

MOUNTED EYEPIECES

The buy of a lifetime at a great saving. Perfect war-surplus lenses set in black-anodized standard aluminum 1¼" O.D. mounts.

F.L.	TYPE	PRICE
12.5 mm (½")	Symmetrical	$ 6.00
16 mm (⅝")	Erfle (wide angle)	12.50
16 mm (⅝")	Triplet	12.50
18 mm (¾")	Symmetrical	6.00
22 mm (27/32")	Kellner	6.00
32 mm (1¼")	Orthoscopic	12.50
35 mm (1⅜")	Symmetrical	8.00
55 mm (2-5/16")	Kellner	6.00
56 mm (2¼")	Symmetrical	6.00

COATED 75 cents extra.

ASTRONOMICAL MIRRORS

These mirrors are of the highest quality, polished to ¼-wave accuracy. They are aluminized, and have a silicon-monoxide protective coating. You will be pleased with their performance.

	Diam.	F.L.	Postpaid
Plate Glass	3-3/16"	42"	$ 9.75
Pyrex	4¼"	45"	13.50
Pyrex	6"	60"	25.00

MIRROR MOUNT

Cast aluminum. Holds all our mirrors firmly with metal clips. Completely adjustable. Assembled, ready to use.

3-3/16" Mount fits our 4½" tubing ..... **$4.00 ppd.**
4¼" Mount fits our 5" tubing ..... **4.00 ppd.**
6" Mount fits our 7" tubing ..... **7.00 ppd.**

Aluminum Telescope Tubing

O.D.	I.D.	Price Per Ft.
2¼"	2⅛"	$1.20 ppd.
3⅝"	3¼"	1.75 ppd.
4½"	4⅛"	2.75 ppd.
5"	4⅞"	2.75 ppd.
7"	6⅞"	3.00 f.o.b.

Focusing Eyepiece Mounts Rack & Pinion Type

The aluminum body casting is finished in black crackle paint and is machined to fit all our aluminum tubing. Has a chrome-plated brass focusing tube, which accommodates standard 1¼" eyepieces.

For 2⅛" I.D. Tubing Postpaid **$12.95**
For 3¼" I.D. Tubing " **12.95**
For 4⅛" I.D. Tubing " **12.95**

REFLECTOR TYPE FOR ALL SIZE TUBING:
Complete with diagonal holder ..... **$ 9.95**

Aluminum Lens Cells

Black Anodized

Cell for Lenses	Cell Fits Tubing	Price
54 mm Diam.	2⅛" I.D.	$ 3.50
78 mm "	3¼" "	6.50
81 mm "	3¼" "	6.50
83 mm "	3¼" "	6.50
110 mm "	4⅜" "	10.50

3X TELESCOPE

Makes a nice low-priced finder. Brand new; has 1" Achromatic Objective. Amici Prism Erecting System, 1⅜" Achromatic Eye and Field Lens. Small, compact, wt. 2 lbs.

Gov't. cost $200. **$9.75**

FIRST SURFACE MIRRORS

Size	Postpaid	Size	Postpaid
14" x 16"	$10.00	5¼" x 7¼"	$3.00
10" x 10"	5.00	5" x 5"	2.00
9" x 11-3/16"	5.00	4" x 5"	1.85
8" x 10"	4.25	4" x 4"	1.50

All mirrors are ¾" thick.

TELEVISION PROJECTION LENS

Brand New, f/1.9, E.F.L. 5 inches. Manufactured by Bausch & Lomb. We purchased entire lot of these discontinued units. Five elements, smallest lens 2", largest 4⅛". Completely assembled 6" in length. All surfaces hard coated. Get this BARGAIN now.

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An Amateur's 12-inch Modified Cassegrainian

THREE HUNDRED working hours, on evenings and weekends over a seven-month period, went into the construction of the 12-inch semiportable reflector pictured here. The instrument, which was built for only $285, fulfills an ambition that H. D. Osborn, 1223 Emerald Ave., Eugene, Ore., has had since he saw Halley's comet in 1910 when he was 13 years old. He is a scientific-instrument maker in the physics department of the University of Oregon.

One of the reasons for designing a modified Cassegrainian optical system was to avoid the hazards of cutting a hole in the mirror, which was purchased from a student. Instead, light from the Cassegrainian secondary is intercepted by a prism placed in front of the primary. This prism deflects the converging beam out to a focal point at the side of the tube, where the eyepiece holder is.

In this size of instrument, the weight of the large primary mirror places the balance point near the lower end of the telescope tube. Therefore, the eyepiece of the modified Cassegrainian design is in a convenient position for observing at al-

H. D. Osborn stands at the eyepiece of his semiportable 12-inch Cassegrainian reflector. The long tube is stabilized by the strut joining its upper half and the declination axle. Near the main pier is wrapped the extension cord for the electric drive. Eugene "Register-Guard" photograph.

THE MARK III
Sidereal Telescope Drive

Bodine Synchronous Motor, Automatic Clutch, Automatic Sidereal Time Circle requiring no calculation for location of objects, R.A. Indicator, Sidereal Time Indicator, Lifetime Quality, Precision Fabrication.

Ramsden Eyepieces
Declination Circles
Hour-Angle Circles

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654 Milwood Ave., Venice, Calif.

DELUXE PYREX
Reflecting Telescope Kits

Our kits have PYREX mirror blank, PYREX tool the same thickness, ample supply of optical quality abrasives, fast polishing cerium oxide, red rouge and pitch. Packed in metal cans.

Size	*Thickness*	*Price*
4¼"	¾"	$ 6.00
6"	1"	$10.50
8"	1½"	$18.75
10"	1¾"	$33.65
12½"	2⅛"	$59.95

ADD POSTAGE: 1st and 2nd postal zones from Detroit, add 5%; 3rd and 4th, add 10%; 5th and 6th, add 15%; 7th and 8th, add 20%. Or we will ship C.O.D.

Send for free catalog of supplies, accessories, and refracting telescopes.

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Everything for the Amateur
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Superior Reflecting Surface.
Guaranteed not to peel or blister.

MIRRORS MADE TO ORDER
MIRRORS TESTED FREE
EYEPIECES | PRISMS
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PRECISION
TRI-TURRET

Holds 3 standard 1¼" O.D. eyepieces. Smooth turn to grooved notch aligns eyepiece precisely, ready to focus for various powers. Suitable for reflectors or refractors. $15.75

ORTHOSCOPIC EYEPIECES
HIGHEST QUALITY • MADE IN U.S.A.

Special four-element design, with fluoride-coated lenses, gives a wide flat corrected field. Standard 1¼" O.D. — E.F.L. 6-8-12-16-24-mm. ..... Postpaid $15.95

Write today for FREE Catalog.

Precision Optical Supply Co.
1001-H East 163rd St., New York 59, N. Y.

MOUNTED BARLOW LENS

This is a simple special lens that fits neatly into your 1¼" focuser and takes any 1¼" O.D. eyepiece. Easily doubles or triples power of your present telescope. No adapters or adjustments necessary. $7.50 postpaid

Unmounted Barlow lens, 1⅛" diam.
$3.00 postpaid

CIRCULAR SPIDERS

New Design
To hold elliptical diagonals. Fully adjustable. Give excellent results. State your diagonal and tube sizes.
$8.50 postpaid

LOW-EXPANSION ELLIPTICAL DIAGONALS

Aluminized, ⅛ wave.

Minor Axis	
¾"	$3.75
1"	3.75
1¼"	5.00
1½"	6.50

MODIFIED RAMSDEN EYEPIECES

¾", ½", ¾", 1⅛", 2", 3", and 4" focal lengths. Attractively mounted in 1¼" O.D. silicon-aluminum bushings.
$5.50 each, $14.00 per set (any 3)

SILICA GEL DRYING AGENT prevents fogging of optics. Comes in small cloth bags, lasts indefinitely. 3 bags, $1.00 postpaid

Write for free catalog.

NYE OPTICAL CO.

2100 Cherry Ave., Long Beach 6, Calif.

most all settings of the telescope. A disadvantage, however, is the long overhang of the tube at its upper end, where it is susceptible to vibration by the wind or local disturbances. To overcome the annoying "shake," Mr. Osborn has added a tie rod between the upper part of the tube and the declination axle, achieving great stability. This connecting rod is held by a collar on the counterweight shaft, so there is no interference with rotation of the instrument around the declination axle.

This close-up of the Osborn mounting shows the small counterweight used for more accurate balancing of the telescope. It is the small cylinder on the short shaft protruding out of the upper end of the larger counterweight. This device often spares the observer the need of shifting the larger weight, which can be inconvenient at night. Photo courtesy Eugene "Register-Guard."

The tube consists of three oil drums fastened together to provide the required length of 85½ inches and a diameter of 15 inches. When the instrument is not in use, a cover protects the 12-inch mirror, the 3½-inch secondary, and the diagonal prism. For minor corrections in balancing the instrument, there is a shaft attached to the main counterweight, carrying a small sliding counterweight.

The polar- and declination-axle units are made of four welded aluminum pistons from a diesel engine, while the extension carrying the main counterweight is a drive shaft from an old Chevrolet car. To drive the telescope in right ascension, a 4-r.p.m. electric motor operates a gear train turning a bronze worm gear at the upper end of the polar axle. For small corrections and for guiding on objects not moving at the sidereal rate, a slow-motion control is provided along the bottom of the tube, just above the polar-axle housing.

The strong triangular support of the base frame is made of irrigation tubing. The 250-pound instrument is easily moved about on four rubber-tired wheels, as seen in the large picture. When the telescope is at its observing location, jack-screws with large disk surfaces at their ends are lowered to level and fix the instrument in place.

Read This Advertisement

Here is a combination of a Barlow and a particular ocular which gives outstanding results. It consists of our new Barlow and our 16.3-mm. (⅝" focal length) Erfle eyepiece. While the Barlow was not specifically designed to work with this eyepiece, it does so to an astonishing degree. All images are sharp and hard to the very edge of the field.

The Barlow gives magnification up to slightly over three times that of the ocular alone. It is achromatic, coated, and mounted to the U. S. standard size of 1.250 inches.

The modified Erfle eyepiece has a field of 75 degrees with excellent eye relief. The combination gives the equivalent focal length of slightly under 6 mm. Many users state it is far superior to any shorter focal length ocular of equivalent magnification.

The Barlow sells for $16.00 postpaid, and the Erfle for $14.75 postpaid. Both are guaranteed to perform as stated above or money refunded.

ORTHOSCOPIC OCULARS—All hard coated, standard 1¼-inch outside diameter.

28-mm.	$15.00	10.5-mm.	$16.25	4-mm.	$17.25
16.3-mm. (Erfle)	$14.75	7-mm.	$17.25	Barlow 3x	$16.00

Telescopics
1000 North Seward Street
Los Angeles 38, Calif.

Warranted to equal or surpass any oculars obtainable anywhere or money refunded.

Finished mirrors, mirror kits, spiders, elliptical flats, focusing devices, aluminizing.

Send for catalogue.

LARGE TELESCOPE OBJECTIVES

FROM 4-INCH TO 20-INCH CLEAR APERTURE

Made from the finest precision annealed optical glass and mounted in well-designed metal cells, these lenses have many important features.

Strain-free mounting
All air-glass surfaces coated
Air-spaced elements
Adequate thickness of lens elements
Push-pull adjustment screws for squaring
Protective screw-on metal cap

Objective lenses are preferred by many observers for the study of fine planetary detail. Moderate apertures can be supplied in time for the coming opposition of Mars.

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Illustrated above is 6" De Luxe Dynascope.

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Custom built to meet a professional's exacting specifications
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Only Criterion could produce such magnificent instruments at such reasonable cost. Combining the latest advances in optical engineering with the old-world skill and patience of master craftsmen, these superb new Dynascopes, custom made, offer top-quality performance. Every feature necessary for superior viewing is precision finished to professional standards. Optical surfaces accurate to 1/10 wave.

The five matched eyepieces are the finest orthoscopic and achromatic. Mechanical features are carefully custom built to assure trouble-free operation. Construction throughout is of lifetime materials. There is both maximum rigidity and easy portability.

Above all, Criterion's strict quality control allows no room for chance. Each Dynascope is doubly tested and inspected; these rigid tests must be flawlessly met before shipment. Your satisfaction UNCONDITIONALLY guaranteed. Yet the price is amazingly low.

6" Standard Model (80 lbs. shipping weight f.o.b. Hartford) **$265**
Also Illustrated: Electric Clock Drive, $80; Setting Circles, $60; Permanent Pedestal, $70.
Write today for full specifications and details of these superior reflecting telescopes.
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Superior Features Include

- f/9 Parabolic Mirror, accurate to 1/10 wave
- Fully Rotating Tube, for comfortable viewing
- Massive Equatorial Mount, adjustable for your latitude
- 5 Matched 1¼" Eyepieces — 3 Achromatic Ramsdens (45X, 76X, 152X) — 2 Orthoscopics (228X, 343X)
- 8 x 50 Achromatic Finder Scope with cross-hairs
- Secondary Support that minimizes diffraction
- Declination Axle, 1½" diameter, with slow motion
- Polar Axle with Needle Bearings on 1½" shaft
- Rack-and-pinion Focusing
- Double-draw Focusing Tube for any eyepiece
- Precision-fashioned 54" Bakelite Tube
- Exclusive Two-way Pier-tripod — a massive 45-pound pier for permanent installation
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Radio Shack **SATELLITE TELESCOPE**

Official design — Built by Radio Shack to Smithsonian Project MOONWATCH specifications for optical tracking!

New! Exclusive at Radio Shack Corp. Special Introductory Price!

IDEAL AND EXACTING SPECIFICATIONS!

Type: refracting telescope normally used in seated position with view directed from front-surface mirror to eye at 90° angle. *Optics:* 6-power, 12° wide field, 68° wide-field eyepiece (over 7-mm. exit pupil) with rubber guard. 51-mm. coated objective, long-throw focusing. *Mounting:* non-reflecting hardwood base, calibrated metal guide, one-knob control for rotating scope on axis. Front-surface mirror has hinged metal cover. Scope overall 2-9/16" dia. x 13¼" long.
Order No. SK-6104, Shipping wt. 4 lbs. $32.95

$32.95

Astronomy Clubs, Schools, MOONWATCH Teams Write for Quantity Discount Prices!

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BOSTON, MASS. NEW HAVEN, CONN.
Over 35 Years of Continuous Service to Electronics, Radio, Science!

MAIL ORDERS TO: RADIO SHACK CORPORATION
167 Washington Street
Boston 3, Massachusetts

☐ 1958 Satellite Telescope (SK-6104) at $32.95
☐ Radio Shack's Optics Bulletin 61
☐ Electronic Buying Guide 58

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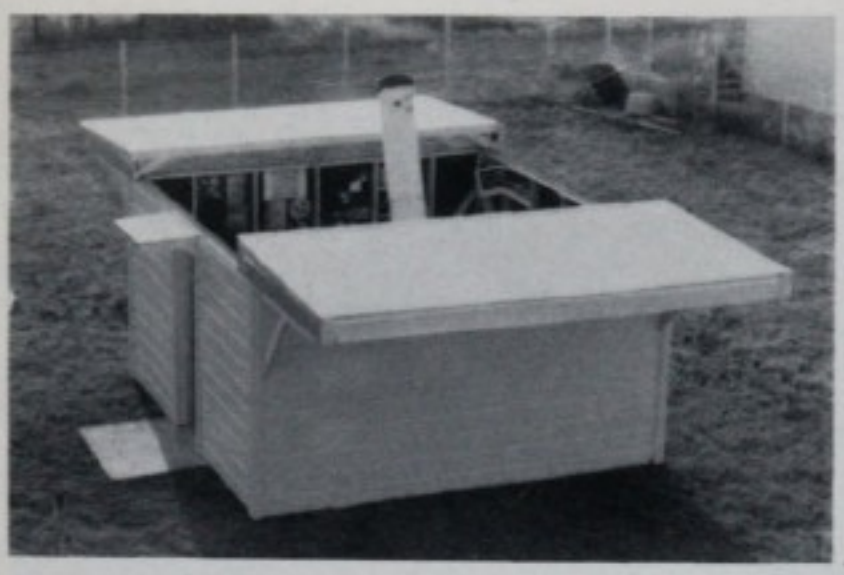
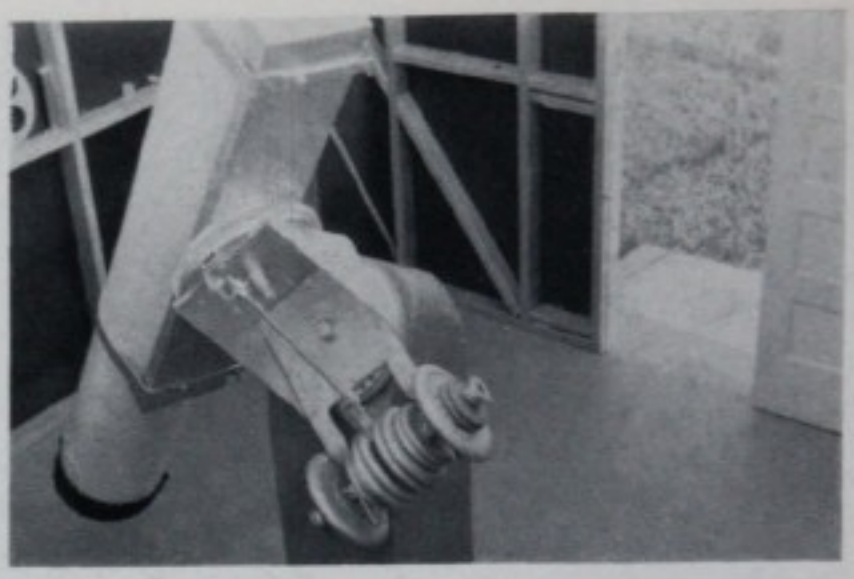




Paul Hudlow's 10-inch reflector is sheltered in this compact observatory with a sliding roof, whose halves can be partly closed to shield the telescope from air currents while observations are being made.

An Inexpensive Observatory in Texas

AFTER 25 years of observing with my telescope on an open mounting in the back yard, carrying the optical parts back and forth from the house, having the ladder tilt in soft ground, and other troubles, I decided that whatever it cost to build a closed-in observatory would be well worth while.

Many types of observatories were considered, and complete plans were drawn for one with a dome and one with a sliding roof. But making a 14-foot dome and track would have been difficult with available equipment and quite costly, so work was started on the observatory pictured here. It is 12 feet square, having been built of 2-by-4 framework and grade A siding. This lumber cost $92; grade B or used lumber would have been much cheaper. The sliding roof, covered with aluminum, was about $32.

The roof opening can be partially closed, leaving a slit just wide enough for observing. As the aluminum roof is very light, skate wheels running in an angle-iron track are strong enough to support it. The roof is anchored from the wind with hangers on the inside using more skate wheels.

The mirror is a 10-inch f/12, designed for lunar and planetary work at the Newtonian focus. Its figure is as perfect as two years of spare time and careful workmanship could make it. The fiberglass tube, from W. R. Parks, is 10 feet long, an unwieldy size that required a special mounting to prevent shaking.

At first glance, the mounting head looks as if it were part of a Springfield, but it is not. It is made of circular bearing plates, as shown in the series of sketches

AN IMPORTANT ANNOUNCEMENT . . . .

To serve better the amateur astronomer and telescope maker, BRANDON OCULARS and BRANDON OBJECTIVES are now being sold at the **Adler Planetarium** in Chicago, Illinois. The planetarium is a nonprofit organization for spreading the knowledge of astronomy in America through exhibits and demonstrations, and assisting in the design and construction of amateur telescopes.

Our oculars and objectives can be obtained immediately by mail, or bought directly from the book counter at the

Adler Planetarium, 900 E. Achsah Bond Drive, Chicago 5, Illinois

ORTHOSCOPIC OCULARS

BRANDON

OCULARS and OBJECTIVES are specifically designed for astronomical observing.

Satisfaction is guaranteed, or your money will be refunded.

Visit your local planetarium — the programs are constantly changing.

ASTRONOMICAL OBJECTIVES

YOU HAVE A CHOICE OF 7 EYEPIECE POWERS!

With a standard f/8 6-inch reflector, our eyepieces give the following powers: 4 mm., 300x; 6 mm., 200x; 8 mm., 150x; 12 mm., 100x; 16 mm., 75x; 24 mm., 50x; 32 mm., 38x.

1. Four-element design gives a flat, beautifully corrected field of 50°, covering more than 160% of the area of the conventional Ramsden for the same power.
2. Precision optical elements, magnesium-fluoride hard coated.
3. Simple take-down for cleaning.
4. Precision metal parts, black anodized for anti-reflection and ground to standard 1¼-inch outside diameter.
5. Clean mechanical design provides for observing ease.
6. Effective focal lengths: 4, 6, 8, 12, 16, 24, and 32 mm.

$15.95 each, postpaid

ANY AMATEUR CAN MAKE HIS OWN REFRACTOR!

Use Brandon astronomical objectives, either 3-inch or 4-inch. Each lens is rigidly tested for its resolution of double stars before being sold. Check these features:

1. Superior optical design utilizing a larger air separation. Color corrected on C and F and hand corrected to reduce residuals to a minimum. Completely free of coma.
2. Glass-air surfaces magnesium-fluoride coated.
3. Quality optical glass precision annealed and held to one ring test-plate match.
4. Mounted in a cell, ready to attach to your own tube of aluminum, brass, steel, or plastic. Cell made to precision tolerances and coated to prevent stray light reflections. Each cell is engraved to show effective focal length and serial number.

3" C.A., 45.8" F.L. . . $62.00 **4" C.A., 61.2" F.L. . . $138.00**

Brandon Instruments

GUAYNABO, PUERTO RICO

OPTICAL FLATS

Pitch Polished, Beral Coated

Rectangular shape
1⅝" x 1⅞"
¼ wave $1.75 each
1/10 wave $4.50 each
Postpaid.

Elliptical shape
Heavy edges to minimize temperature effects.
1¼" minor axis.
¼ wave $4.00 each
1/10 wave $6.50 each
Postpaid.

BERAL COATINGS — same optical characteristics as aluminum — mechanically more durable — not over-coated — may be removed without harming glass surface. Prices for Beral coating telescope mirrors: 4" diam. - $2.75, 6" - $3.50, 8" - $4.50, 10" - $6.50, and 12½" - $9.75 each, f.o.b. Skokie.

LEROY M. E. CLAUSING
8038 Monticello Ave. Skokie, Ill.

HELPFUL HINTS TO OBSERVERS!

The free literature offered in the Frank Goodwin ad below includes the following subjects: telescope observational techniques and methods; cutting down sunlight externally in viewing the sun; cleaning mirrors; sealing objectives against interelement air-space dewing; how to approximate off-axis performance with your reflector by a simple black-paper mask on mirror, occulting diffraction of diagonal and struts. (Also how the Goodwin Resolving Power lens is positively guaranteed to make any good telescope perform like a larger one, for reasons stated in the ad below.)

FRANK GOODWIN
345 Belden Ave., Chicago 14, Ill.

NEW THRILLS FROM YOUR TELESCOPE!

Sharper images, wider field, more light at higher powers! A startling statement positively proven in 16-page telescopic educational matter, plus many helpful hints, sent free on receipt of self-addressed long envelope bearing 9c return postage.

First, the Goodwin Resolving Power lens placed in front of eyepiece gives three times the magnification on each by increasing the effective primary focal length up to three times, yet extends eyepiece out no more than two inches from normal. This alone sharpens definition.

Next, by achieving your highest powers on more comfortable low-power eyepieces, you lessen image deteriorations due to short-focus acute bending of the convergent beam, since all usual eyepieces are f/1 or less. Again sharper images from this highest precision lens.

Third, you get greater illumination and wider field by relieving tiny aperture restrictions of higher-power eyepieces.

The Resolving Power lens is achromatic, coated, gives flat field sharp to the edge. Here is astonishment! Price $23.50 in 4" long adapter tube fitting standard 1¼" eyepiece holders ONLY. (Also adaptable to Unitrons; state if Unitron.) Money back if not positively thrilled after two weeks trial! Used and praised by legions!

No COD's—Colleges and Observatories may send purchase order.

FRANK GOODWIN
345 Belden Ave., Chicago 14, Ill.

in Figs. 3 and 4 of Russell W. Porter's article on mountings in *Amateur Telescope Making — Book One*, page 132. My mounting has the advantages outlined there, and since its bearings are 14 inches in diameter it has proven steady.

The bearings are made of flywheels which were turned on each other, using fine carborundum powder, until they had a smooth fit. The angle piece is made from 14-inch steel plates, reinforced and welded at a right angle. To minimize vibration, there is a short heavy counterweight consisting of bar-bell weights supported by strap-iron strips fastened to the angle piece that fits over the right-ascension axle. Some of the stress is taken up by the tie rod between the counterweights and the plate that supports the declination bearing.

The clock drive I am now working on will have a worm gear engaging the teeth of the polar-axis flywheel.

PAUL HUDLOW
P. O. Box 124
Breckenridge, Tex.

An Easily Built Adjustable Slit

IN THE FINAL STAGES of Foucault testing a mirror's figure, a precision-made slit is best for critically illuminating the surface contours. Shown in the diagram is a slit whose width is easily adjustable by means of an external strip, which exerts pressure on the two razor blades forming the slit jaws. Turning a wing nut changes this pressure to bring the edges closer together or farther apart.

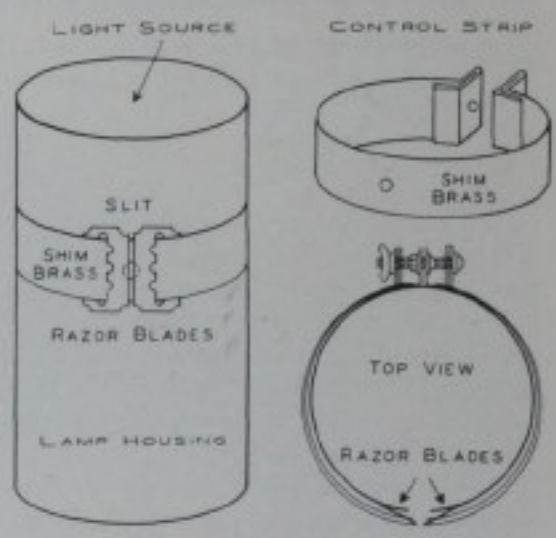
The slit arrangement is superimposed on a 3/16" round hole, cut at a convenient observing height in the wall of the upright can or other housing for the light source. A strip of shim brass is cut to a suitable length, its ends being bent at right angles and perforated to take two small bolts. Each end is notched between the pair of bolt holes to allow clearance for a single bolt that will fasten another strip at the same point.

In the center of the first strip, a 5/32" hole is cut. The two double-edge razor blades are mounted by running the brass strip through their center slots as illustrated. The strip is placed around the housing, its hole superimposed upon the one in the housing, while the two edges of the blades are made parallel and centered over both holes. The strip is then fastened tightly around the can by means of the bolts in its extremities.

The parallel, center edges of the razor blades now protrude from the strip running through them. The slit-width control is provided by the second strip of shim brass (shown at the upper right in the diagram) which is wrapped around the inner strip and the blades, with its ends bent at right angles and fitting just outside the notched ends of the inner strip.

This outer piece has a ⅛" hole centered over the slit and the other holes. A single round-head bolt, with washer and wing nut, is run through a hole in each end, centered to coincide with the notches in the ends of the inner strip. This single bolt holds the outer strip in place, and its wing nut is turned to adjust the slit width by increasing or reducing the pressure on the razor blades.

A compression spring, ⅜" diameter, may be inserted over the threads of the adjustment bolt, so that the ends of the control strip are always pushed firmly toward the extremities of the bolt.



Amateur telescope makers find an adjustable slit a great convenience for illuminating the mirror during the delicate task of Foucault testing. These diagrams show the chief parts of the writer's simple and easily constructed slit mechanism. His idea may also be adapted for spectroscope slits.

This slit light source can be used with a Foucault tester that has a small right-angle prism over the pinhole to direct the light toward the mirror from a point closer to the optical axis than the radius of the lamp housing will allow. A device of this kind is pictured on page 32 of Allyn J. Thompson's *Making Your Own Telescope*.

KELVIN MASSON
338 Plaza Ave.
St. Louis 21, Mo.

PANCRO mirrors, inc.

Reg. U.S. Pat. Off

Your mirror may now have the same aluminum and quartz over-coating, with high reflection, durability, and guaranteed permanent adhesion, that we are giving Cave Optical Co. for the Astrola telescopes. Your mirror will be carefully packed and on the way back to you within 24 hours.

6-inch.....	**$6.50**	10-inch.....	**$11.25**
8-inch.....	**$8.50**	12-inch.....	**$16.00**

Prices are f.o.b. Los Angeles.

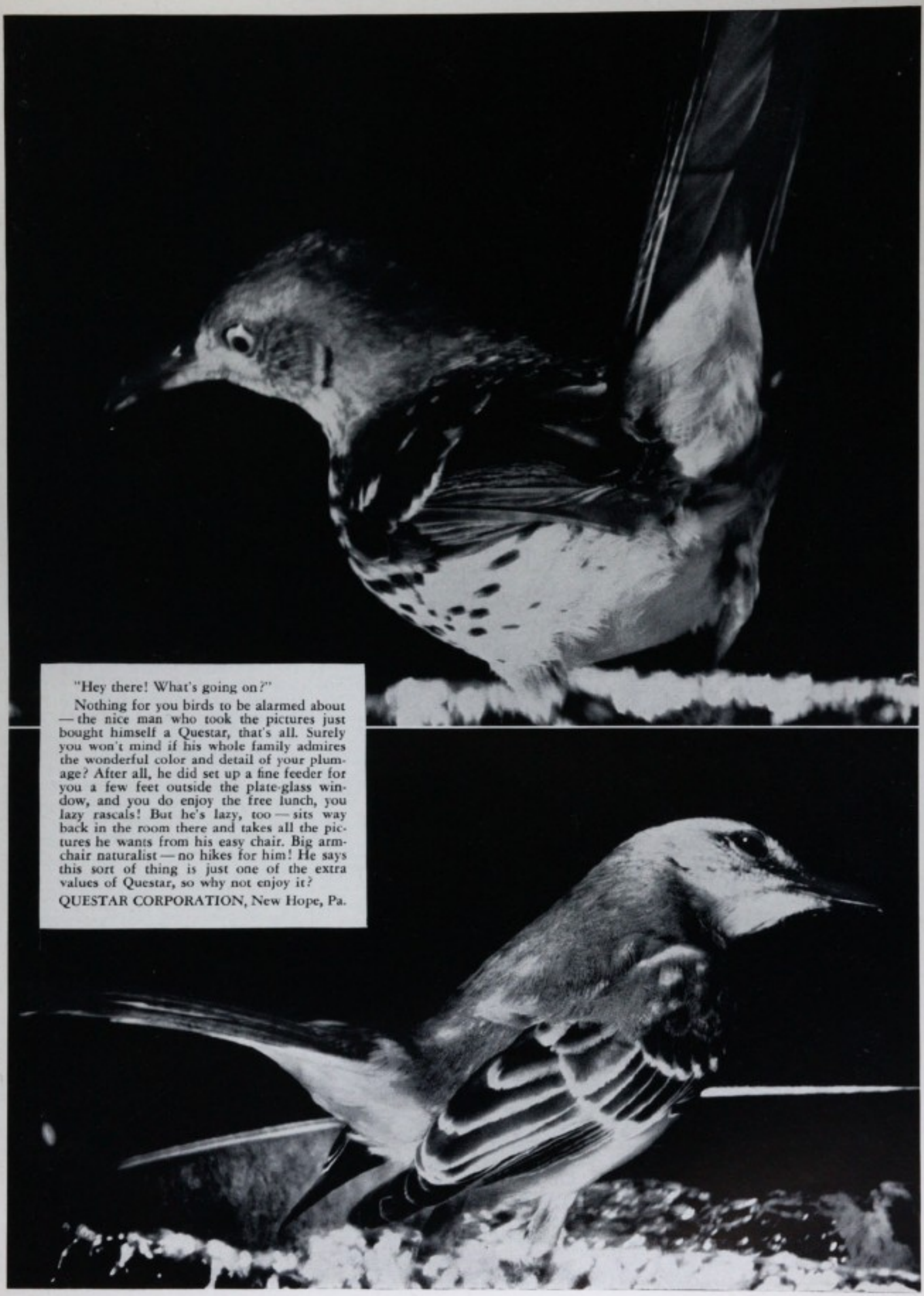
Since 1933

PANCRO MIRRORS, INC.
Research and Production Laboratories
2958 Los Feliz Blvd., Los Angeles 39, Calif.

"Hey there! What's going on?"

Nothing for you birds to be alarmed about — the nice man who took the pictures just bought himself a Questar, that's all. Surely you won't mind if his whole family admires the wonderful color and detail of your plumage? After all, he did set up a fine feeder for you a few feet outside the plate-glass window, and you do enjoy the free lunch, you lazy rascals! But he's lazy, too — sits way back in the room there and takes all the pictures he wants from his easy chair. Big armchair naturalist — no hikes for him! He says this sort of thing is just one of the extra values of Questar, so why not enjoy it?

QUESTAR CORPORATION, New Hope, Pa.



ANNOUNCEMENT

Your city postal *zone number* helps the post office deliver your mail more efficiently and economically. And when your zone number is used, you receive faster mail service.

Use your postal zone number in your correspondence with us – and, please, be extra sure you include it when ordering or renewing your subscription to *Sky and Telescope*.

CELESTIAL CALENDAR

Universal time is used unless otherwise noted.

OCCULTATION PREDICTIONS

March 13-14 **Rho Sagittarii** 4.0, 19:19.2 −17-55.7, 24. Im: **H** 12:40.4 −1.3 +0.9 96; **I** 12:54.8 −1.1 +1.6 72.

March 21-22 **Mercury** −0.8, 1:01.3 +7-45.1, 2. Im: **B** 23:27.4 2; **D** 23:17.2 −0.7 +2.3 19. Em: **B** 23:46.2 332; **D** 23:57.8 0.0 −4.2 314.

March 25-26 **68 Tauri** 4.2, 4:23.1 +17-50.0, 6. Im: **A** 3:00.7 +0.2 −1.7 110; **B** 2:55.7 0.0 −1.7 103; **C** 3:08.5 +0.2 −2.2 125; **D** 2:59.1 0.0 −1.9 113; **E** 3:07.7 0.0 −3.0 137.

March 28-29 **Lambda Geminorum** 3.6, 7:15.7 +16-37.1, 9. Im: **H** 7:47.6 −0.5 −1.0 85; **I** 7:34.9 −1.0 −0.4 53.

April 5-6 **Alpha Librae** 2.9, 14:48.6 −15-52.1, 17. Im: **A** 3:02.4 +0.2 −1.6 165; **B** 2:59.2 −0.1 −0.7 154. Em: **A** 3:38.9 −1.9 +2.7 234; **B** 3:44.3 −1.5 +2.0 244; **D** 3:29.7 −1.9 +3.8 225.

For stations in the United States and Canada, usually for stars of magnitude 5.0 or brighter, data from the *American Ephemeris* and the *British Nautical Almanac* are given here, as follows: evening-morning date, star name, magnitude, right ascension in hours and minutes, declination in degrees and minutes, moon's age in days, immersion or emersion; standard-station designation, UT, **a** and **b** quantities in minutes, position angle on the moon's limb; the same data for each standard station westward.

The **a** and **b** quantities tabulated in each case are variations of standard-station predicted times per degree of longitude and of latitude, respectively, enabling computation of fairly accurate times for one's local station (long. **Lo**, lat. **L**) within 200 or 300 miles of a standard station (long. **LoS**, lat. **LS**). Multiply **a** by the difference in longitude (**Lo** − **LoS**), and multiply **b** by the difference in latitude (**L** − **LS**), with due regard to arithmetic signs, and add both results to (or subtract from, as the case may be) the standard-station predicted time to obtain time at the local station. Then convert the Universal time to your standard time.

Longitudes and latitudes of standard stations are:

A	+72°.5,	+42°.5	**E**	+91°.0,	+40°.0
B	+73°.6,	+45°.5	**F**	+98°.0,	+31°.0
C	+77°.1,	+38°.9	**G**	Discontinued	
D	+79°.4,	+43°.7	**H**	+120°.0,	+36°.0
			I	+123°.1,	+49°.5

VARIABLE STAR MAXIMA

March 2, U Ceti, 022813, 7.5; 2, V Canum Venaticorum, 131546, 7.1; 7, T Centauri, 133633, 6.1; 7, V Coronae Borealis, 154639, 7.4; 15, V Bootis, 142539, 7.9; 16, S Carinae, 100661, 5.7; 17, R Geminorum, 070122a, 7.1; 18, R Octantis, 055686, 7.9; 19, S Ursae Majoris, 123961, 7.9; 20, R Centauri, 140959, 5.9; 27, R Serpentis, 154615, 6.8; 29, T Aquarii, 204405, 7.9.

April 6, T Columbae, 051533, 7.6; 9, R Cancri, 081112, 6.8.

These predictions of variable star maxima are by the AAVSO. Only stars are included whose mean maximum magnitudes are brighter than magnitude 8.0. Some, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for maximum. The data given include, in order, the day of the month near which the maximum should occur, the star name, the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern), and the predicted magnitude.

MINIMA OF ALGOL

March 2, 20:29; 5, 17:18; 8, 14:08; 11, 10:57; 14, 7:46; 17, 4:36; 20, 1:25; 22, 22:14; 25, 19:03; 28, 15:52; 31, 12:42. April 3, 9:31; 6, 6:20; 9, 3:09; 11, 23.58.

These minima predictions for Algol are based on the formula in the 1953 *International Supplement* of the Krakow Observatory. The times given are geocentric; they can be compared directly with observed times of least brightness.

UNIVERSAL TIME (UT)

TIMES used in Celestial Calendar are Greenwich civil or Universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. If necessary, add 24 hours to the UT before subtracting, in which case the result is your standard time on the day preceding the Greenwich date shown.

SKY-GAZERS EXCHANGE

Classified advertising costs 25 cents a word, including address; minimum charge, $3.00 per ad. Only one *for sale* ad per issue for each advertiser. *Remittance must accompany order.* Insertion is guaranteed only on copy received by the 20th of the second month before publication; otherwise, insertion will be made in next issue. We cannot acknowledge classified ad orders. Sky Publishing Corporation assumes no responsibility for statements made in classified ads, nor for the quality of merchandise advertised. Write Ad Dept., *Sky and Telescope*, Harvard Observatory, Cambridge 38, Massachusetts.

PYREX BLANK, 16" diameter, 3" thick, new, excellent condition, $100.00 plus postage. Mrs. Gladys Litwin, 811 Lafayette St., Watertown, Wisc.

FINE ANASTIGMATS, barrel mounts, iris. 8", f/2.9, $37.50; 14", f/5.6, $59.50; 20", f/6.3, $57.50; 30", f/6.3, $79.50. Baer's, 741 State St., Lancaster 2, Pa.

FOR SALE: 143 issues of *Sky and Telescope*, from February, 1946, to December, 1957, complete. George O'Hare, 758 Burchett St., Glendale 2, Calif.

FOR SALE: 12" f/7 aluminized mirror, excellent figure. Best reasonable offer takes it. D. A. Batchelor, 1400 Grandin Ave., Pittsburgh 16, Pa.

FOR SALE: 4" altazimuth 1957 Unitron complete, plus 40-mm. ocular, $345.00. L. E. Schmidt, Rte. 2, Box 155 AA, Lebanon, Ore.

PYREX MIRROR, 16" diameter, 3" thick, 2" center hole, f/4.7, precision ground and polished by Carreau. Heavy English fork mount. Castings and tube unfinished. Completed telescope will weigh 2,000 pounds. Will agree to complete telescope. Investment, $1,800.00; will consider fair offer. J. O. McMillan, 1225 Jackson, Wichita 5, Kans.

REFRACTOR, 4", rack and pinion, finder, Unibex, and cradle. No mount. $225.00. Send stamp for photo. Ed Newman, 2041 Colonial, Roanoke, Va.

SIDEREAL DRIVE for telescope or camera, track stars, accurate simple gearless design, make transparencies, complete plans, $1.00. "Space Chart," proportioned celestial bodies, distances, notes, also constellation maps, $1.00. L. Mussgnug, Box 74, Bethel, Conn.

CANADIAN AMATEURS: America's best-selling line of refracting telescopes and accessories now available from Canada's largest optical specialists. Save customs clearance and extra duty. Carsen Instruments, Ltd., 88 Tycos Dr., Toronto 10, Canada.

ALUMINUM TUBING, sizes 2", 3", 4", 5", 6", 7", and 8" outside diameter. Any lengths up to 30 feet. Pesco-A, Box 363, Ann Arbor, Mich.

TELESCOPES: 8-power M-17 elbow telescopes, as described optically in the April, 1957, issue, page 292. Government cost $175.00. Optically perfect, equipped with threaded standard tripod adapter, also usable for telephoto photography. Satisfaction guaranteed or money refunded. Price, $14.85 postpaid. Shelsy and Co., 250 W. Broadway, New York 13, N. Y.

SPHERICAL SCALE: Draw accurate space figures in minutes. Solve astronomical triangles without math. With booklet, $2.95. Free bulletin. Sphere Grid, 4550 MacArthur Blvd. N. W., Washington 7, D. C.

FOR SALE: De luxe Questar, $800.00. Joseph Costes, 440 Dogwood N. E., Ada, Mich.

FOR SALE: 2.4" Unitron altazimuth, excellent condition, $85.00. Alan Yates, 507 W. Blackman, Harvard, Ill.

WORLD-WIDE *Bibliography for ATM's*, 25¢. Kelvin Masson, 338 Plaza Ave., St. Louis 21, Mo.

PYREX MIRROR, 10" diameter, paraboloid, f/8, excellent characteristics, unsurfaced, $100.00 plus shipping. B. Buckingham, 211 E. Melbourne Ave., Silver Spring, Md.

KOLLSMAN drift sights, consisting of telescope and recorder, $19.95. Kodak Snooperscopes with 5" Schmidt, f/0.5, system, $29.95. Air Force Equi-Angulator, $95.00. V. Bedrosian, Box 23, Saylesville, R. I.

FOR SALE: 6" Newtonian, eyepiece, Barlow, finder, tube rotates on bearings, equatorial mounting, and the like, $200.00. Tom Borlik, 1027 Canterbury Dr., South Bend 28, Ind.

REFLECTOR, Criterion's 4" Dynascope, 167x, 130x, 65x, $40.00 f.o.b. Gordon Bergman, Union Rd., Caseyville, Ill.

NEW, rubber "Hex-Lap" mat. Molds perfect pitch lap in minutes. Over 150 facets with exclusive hexagon pattern, scientifically designed to give fast, zoneless polishing. Custom made for each mirror size and die cut for accuracy. For 6" mirror, $3.00; 8", $4.00 postpaid. Other sizes soon. Glendale Mechanical Lab, 1359 Romulus Dr., Glendale 5, Calif.

EQUATORIAL MOUNTS: Four sizes. Priced from $21.95 to $74.95. Optical items accepted in trade. Literature on request. Marvin Stell, 600 E. 5th, Coleman, Tex.

NEW imported 20 x 50 powerhouse center-focus binoculars, finest coated optics, regularly $89.50, now $49.50. 6" air-spaced objective, guaranteed best, $475.00. Help earn that telescope with the Eldorado gold and rare-earths recovery machine, new electrostatic principle, recovers finest gold heretofore impossible to save, 98% efficient, $145.00. Brayton Optical Exchange, 120 Beachway, Monterey, Calif.

DISCOUNT PLAN explained in 1958 catalogue of telescope making supplies. Send 25c, deductible from first order. Quality Optics, Walbridge, Ohio.

FOR SALE: 7 x 50 and also 6 x 30 binocular eyepieces, spiral focusing, coated eye lens, $3.00 each. Prisms — right-angle 7/8" x 7/8" face, 1-5/16" hypotenuse, $1.00 each. Tank periscope prisms, right-angle, 2 1/8" hypotenuse, 5 3/4" long, in metal and plastic housing, two for $1.50. All postpaid. Supplies are limited. Satisfaction or money refunded. Charles E. Roberts, 730 4th St., Fremont, Ohio.

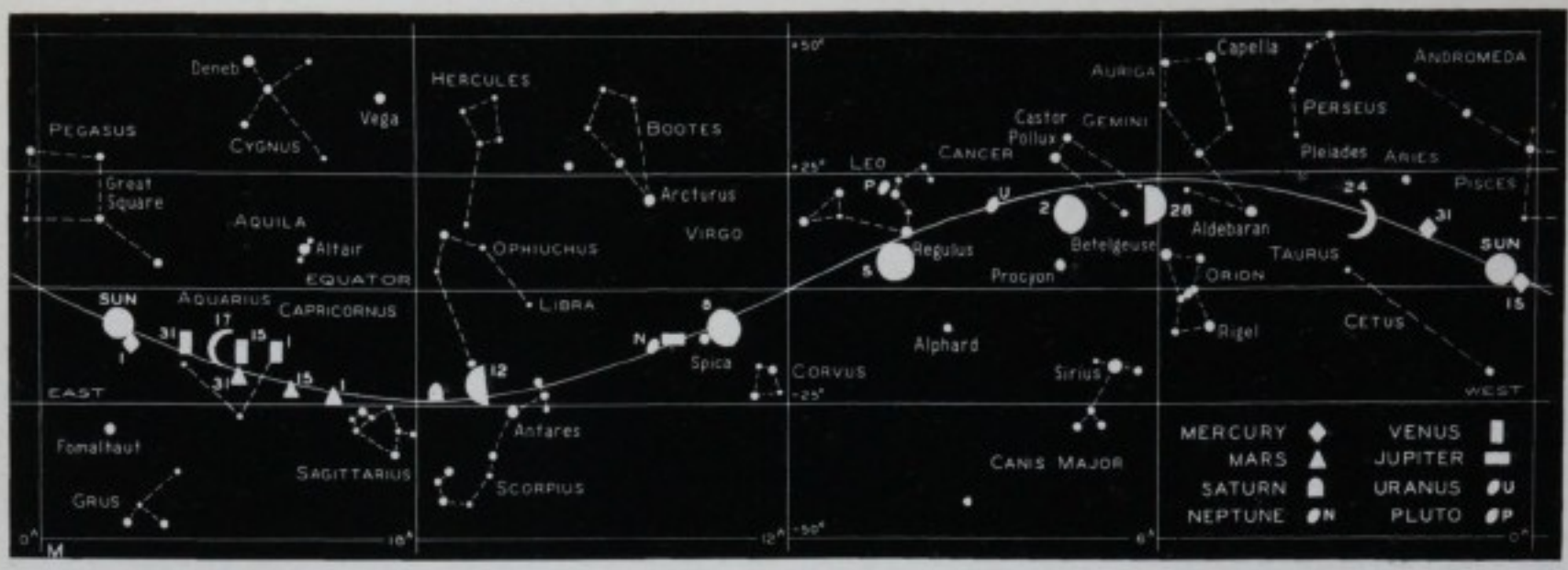
BEGINNER'S Telescope Kit: $5.00 each, all parts, and 3 lenses. Make 8-power astronomical telescope. Perfect for youngsters and school projects. Frank Myers, 19200 N. Park Blvd., Shaker Heights, Ohio.

INTERESTED in astronomy as a career? *Vocational and Professional Monographs: Astronomy* by Freeman D. Miller describes personal qualifications, scholastic training, and job opportunities. $1.00 postpaid. Send to Box B, *Sky and Telescope*, Harvard Observatory, Cambridge 38, Mass.

MONEY-MAKING opportunity for enthusiastic amateur astronomers. See our ad on page 260. 6" Stellarscope, 1/8 wave, guaranteed 25 years, full price $99.50. Wanted: Old mirrors for new. Send your old mirror and just $10.00 more than our regular refiguring charge — we'll send you, by return mail, a brand-new 1/8-wave Stellartron mirror in exchange. Trade in your small telescope for a 1/8-wave 25-year-guaranteed Stellarscope. Send a snapshot and specifications of your scope — tell us which Stellarscope you're interested in. We will allow up to half your original purchase price on trade-in — and will send you our bid by return air mail, plus catalogue. Stellar Scientific Instruments, 1015 W. 6th St., Santa Ana, Calif.

FOR SALE: Giant 3" altazimuth Unitron refractor; erecting prism; diagonal; eyepieces for 200x, 131x, 96x, 67x, and 48x; wooden case; rigid, portable elevating steel base. Perfect, almost new. A $300.00 value. Sacrifice at $169.95. Better buy now before someone else gets it. Robert Lovett, Jackson Village, Jackson, S. C.

POSITIONS OPEN to persons with backgrounds in mathematics, physics, astronomy, and electronics, for work involving photographic reduction, electronic computing, orbit computations, and observing (both domestic and foreign). Submit U. S. Civil Service Form 57, in triplicate, to Dr. J. A. Hynek, Smithsonian Astrophysical Observatory, 60 Garden St., Cambridge 38, Mass.



THE SUN, MOON, AND PLANETS THIS MONTH

The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month or for other dates shown. All positions are for 0h Universal time on the respective dates.

Mercury is in superior conjunction on March 3rd, and on the 29th reaches eastern elongation 18° 52′ from the sun, a very favorable opportunity for northern observers. On this date the planet will be magnitude +0.1, setting about $1\frac{2}{3}$ hours after the sun. Mercury may be easily seen in the western sky for about a week before and after elongation; its magnitude on the 22nd will be −0.8 and on April 5th +1.1. This planet will be occulted by the moon on the 21st; details are given in Occultation Predictions.

Venus is a very prominent object low in the southeastern sky, rising about $2\frac{1}{4}$ hours before the sun in mid-March. It reaches greatest brilliancy on the 4th, when its magnitude is −4.2 and the disk is one-quarter illuminated. Venus will be close to the moon on the morning of the 16th, conjunction occurring at 11:00 UT with Venus 1° 17′ south, as seen from the earth's center.

Earth arrives at heliocentric longitude 180° on March 21st at 3:06 UT. Spring commences in the Northern Hemisphere, and autumn in the Southern; days and nights are approximately equal everywhere on this date.

Mars is moving from Sagittarius into Capricornus. This +1.3-magnitude red planet rises about $2\frac{1}{2}$ hours before the sun, and may be seen low in the southeast at dawn.

Jupiter is in Virgo, not far from Spica. It rises about 9 p.m. local time in mid-month, and is visible for the rest of the night as a −1.9-magnitude object. On the 15th, Jupiter's telescopic disk will have an equatorial diameter of 42″.6 and a polar diameter of 39″.8.

Saturn reaches western quadrature on the 16th, rising about 1:20 a.m. local time. It appears of magnitude +0.7, near the Sagittarius-Ophiuchus border.

Uranus is in slow retrograde motion in Cancer, and on the 15th is at right ascension 8h 42m, declination +18° 56′. It crosses the meridian at about 9:10 p.m. local time, and is easily visible in field glasses.

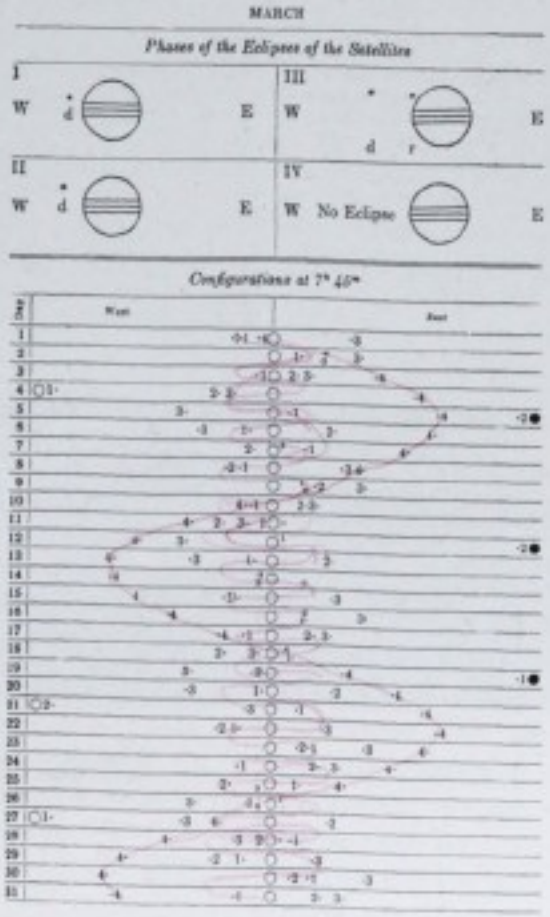
Neptune is in eastern Virgo, at right ascension 14h 11m, declination −11° 18′, on the 15th. Telescopically it has a tiny disk 2″.5 in diameter.

W. H. G.

JUPITER'S SATELLITES

The configurations of Jupiter's four bright moons are shown below, as seen in an astronomical or inverting telescope, with north at the bottom and east at the right. In the upper part, *d* is the point of disappearance of the satellite in Jupiter's shadow; *r* is the point of reappearance.

In the lower section, the moons have the positions shown for the Universal time given. The motion of each satellite is from the dot toward the number designating it. Transits over Jupiter's disk are shown by open circles at the left, eclipses and occultations by black disks at the right. The chart is from the *American Ephemeris and Nautical Almanac*.



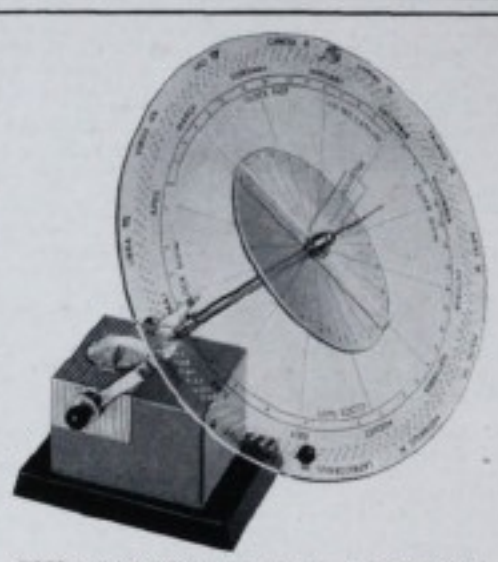
MOON PHASES AND DISTANCE

Full moon	March 5, 18:28
Last quarter	March 12, 10:48
New moon	March 20, 9:50
First quarter	March 28, 11:18
Full moon	April 4, 3:45

	March	Distance	Diameter
Perigee	6, 9h	222,000 mi.	33′ 26″
Apogee	20, 19h	252,600 mi.	29′ 23″
	April		
Perigee	3, 21h	221,800 mi.	33′ 29″

MINOR PLANET PREDICTIONS

Predictions for minor planets for this month appeared on page 206 of the February issue.



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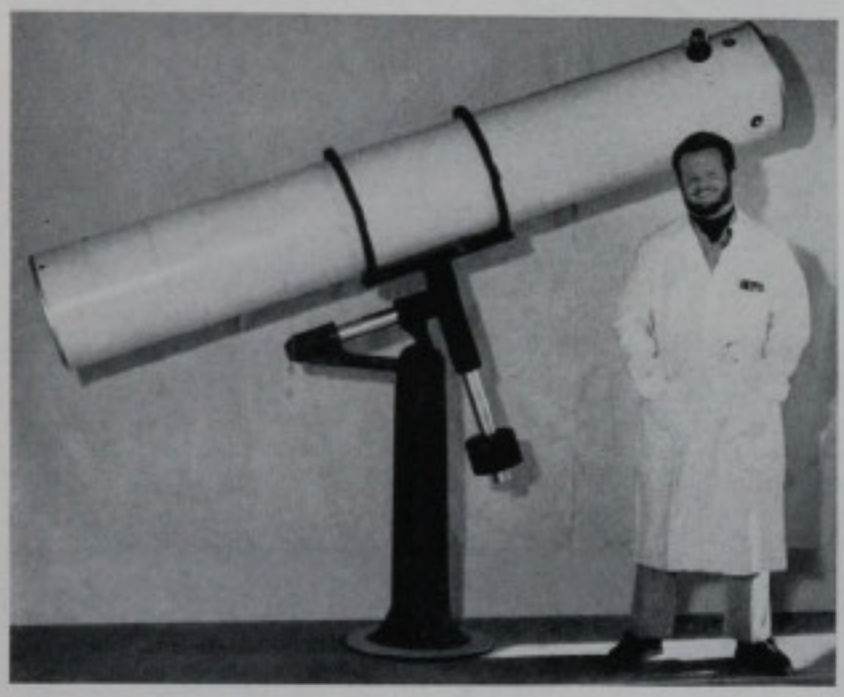

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GALACTIC EQUATOR
NORTH POLE
NORTH ECLIPTIC POLE
SOUTH CELESTIAL POLE
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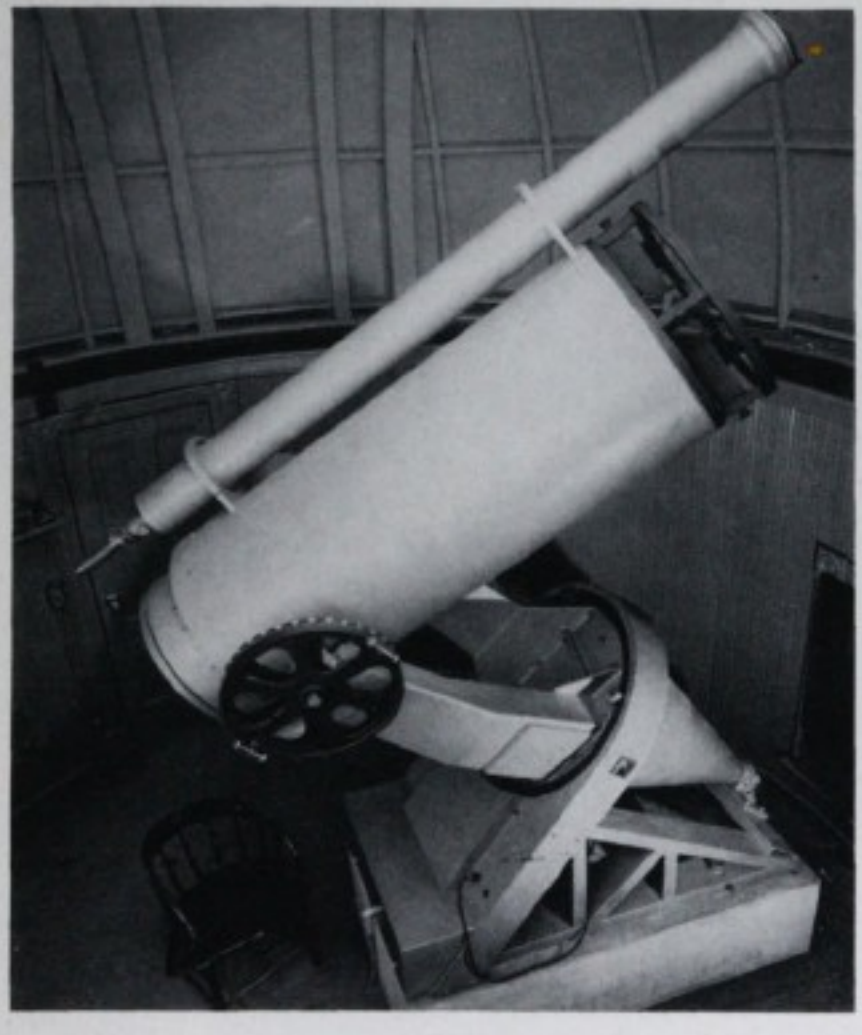

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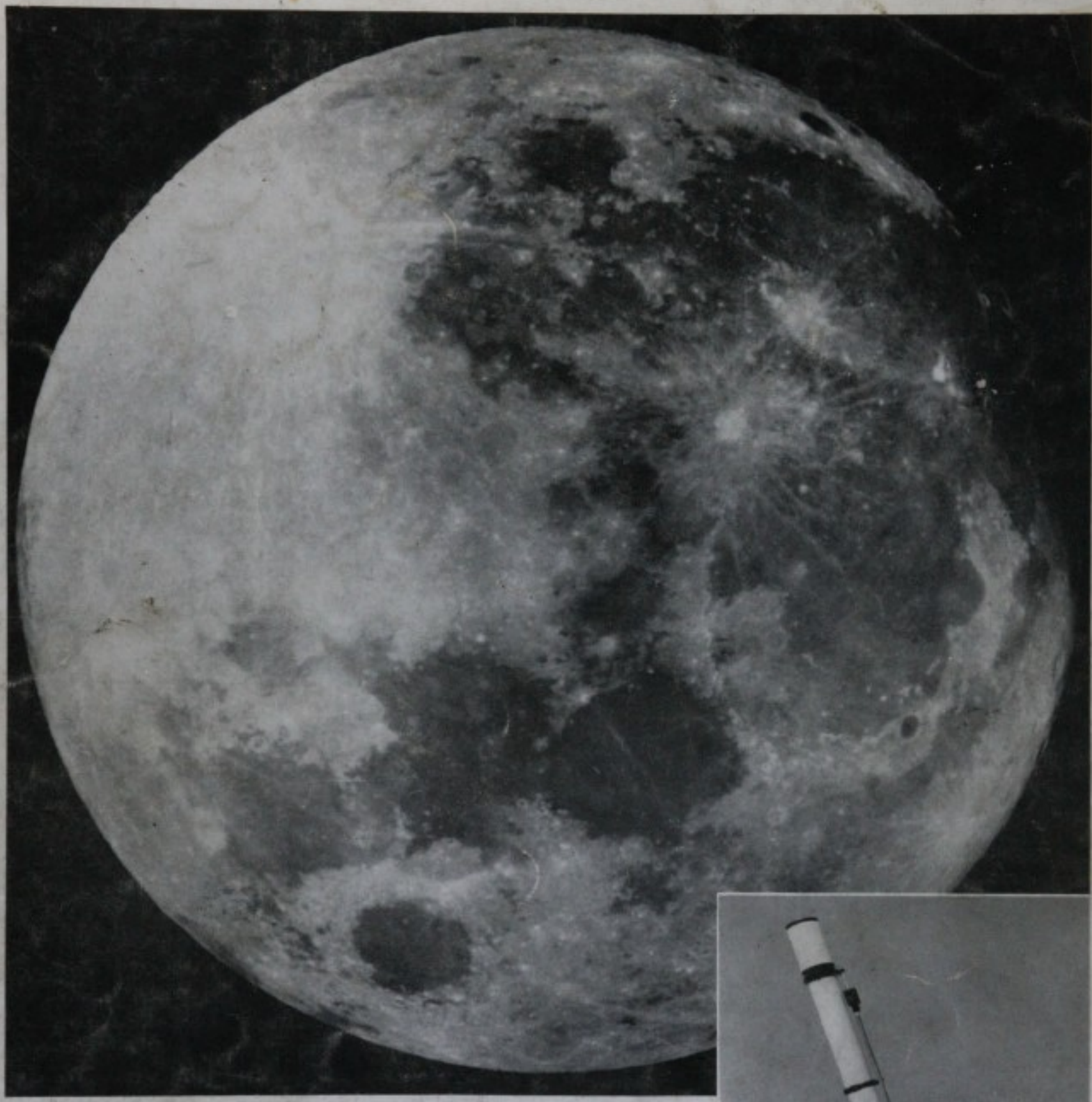

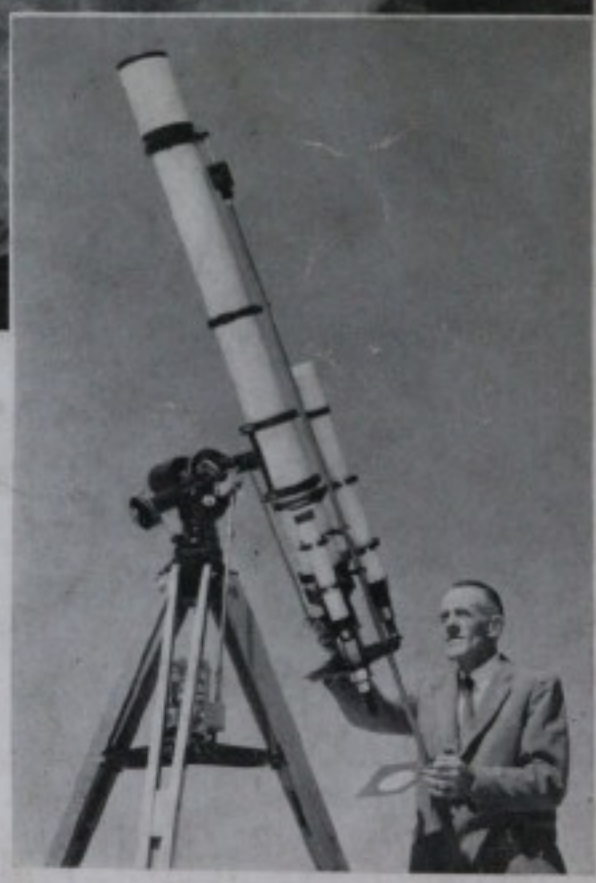

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The full moon's lack of shadows and contrast make it a notoriously difficult subject for the astrophotographer. Those who have made the attempt will appreciate the thoroughly professional quality of the photograph shown here. It was taken by Bryant W. Pocock, of Lansing, Michigan, using his UNITRON 4" Photo-Equatorial Refractor Model 160 and Astro-Camera 220. Mr. Pocock, whose interests lie in the field of engineering, is an active member of the Lansing Amateur Astronomy Club. He teaches courses in astronomy at Michigan State University and at the Lansing Adult Education Center.

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See pages 242 and 243.

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